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COTTONWOOD DAM

MANUAL FOR
OPERATION AND MAINTENANCE

State Water Projects Bureau
Water Resources Division
Department of Natural Resources and Conservation
1424 9th Avenue
P. O. Box 201601
Helena, MT 59620-1601

Originally Published June, 1995
Revised April 2005

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PROJECT DESCRIPTION

Overview

Cottonwood Dam is owned by the Montana Department of Natural Resources and Conservation (DNRC) and is managed by the State Water Projects Bureau (SWPB) of the DNRC. The Shields Canal Company (herein called the "association") operates and maintains the dam.

The dam is located on Cottonwood Creek, approximately 3 miles northwest of town of Wilsall in Park County. The reservoir impounds runoff from a drainage area of 34 square miles located in Park and Gallatin Counties (See Figures 1 and 2). Figure 3 provides a general layout of the dam, spillway and outlet works. Figure 4 shows the location of the monitoring wells.

Water from the reservoir is primarily used for irrigation. The reservoir is also used for water-based recreation.

Embankment

The zoned earthfill dam and earthfill dike were completed in 1953. The dam is 39-feet-high and 610-feet-long while the dike is up to 8-feet-high and 825-feet-long. In 1986 significant construction was completed to rehabilitate the spillway and riprap on the upstream face of the dam.

Outlet Works

The dam's outlet works consist of a wet tower and a single 36-inch diameter slide gate with controls at the top of the tower. The low-level outlet conduit consists of 197 feet of 10 gauge, 36-inch diameter corrugated metal pipe double bituminous coated (inside and outside) and paved invert.

In 2003, the Bureau of Reclamation performed a visual inspection and ultrasonic thickness survey of the corrugated metal outlet pipe. The ultrasonic thickness survey results indicated that the pipe wall thickness is greater than the wall thickness originally specified. This is not unusual, as pipe manufacturers tend to make the pipe wall thickness slightly larger than the thickness specified to ensure they meet minimum wall thickness requirements. Due to the extra wall thickness, the Bureau concluded the surface rusting on the corrugated metal pipe was not a concern at that time.

Spillway

The spillway is located in the right abutment. In 1986, the dam underwent a spillway rehabilitation project that increased the capacity of the spillway. The project also constructed a guard dike, a new baffled apron chute and increased the height of the chute sidewalls. The purpose of the guard dike is to maintain storage in the reservoir and allowed the removal of the flashboards on the spillway thus increasing the ultimate capacity of the spillway.

The spillway is an uncontrolled concrete chute with a 70-foot-wide guard dike and a 20-foot-wide ogee crest at the throat of a 20-foot-wide chute with concrete baffle blocks. The guard dike is at elevation 5,102.5 feet that is the same elevation as the pre-existing wooden flashboards (the flashboards were removed during the rehabilitation work).

DRAINS

The drawings for the dam show a toe drain that exits into the outlet channel downstream from the outlet-spillway stilling basin. The drain has not been located. An attempt was made with a backhoe in 1985 to locate the drain that proved to be unsuccessful.

Approximately 15 feet downstream from the outlet wingwall on the left side of the outlet channel, water is flowing into the channel. This may be the exit for the toe drain. The flowing water at this location was first observed in 1992. The drawings show the approximate drain exit point into the channel near this location.

When the spillway was reconstructed in 1986, drains were installed under the floor to collect the seepage that flows through the right abutment. The drains consist of a drain located outside and adjacent to each of the spillway sideways in filter gravel, a central drain with collector pipes under the spillway floor in filter gravel, and two side drains adjacent to the center drain under the floor. The outside wall drains exit into the spillway through the downstream side of one of the baffle blocks. The under-floor drains exit through the spillway floor above the normal water surface of the stilling basin. There is gravel underlying the toe of the spillway so that excess seepage can flow through weep/drain holes in the spillway end wall.

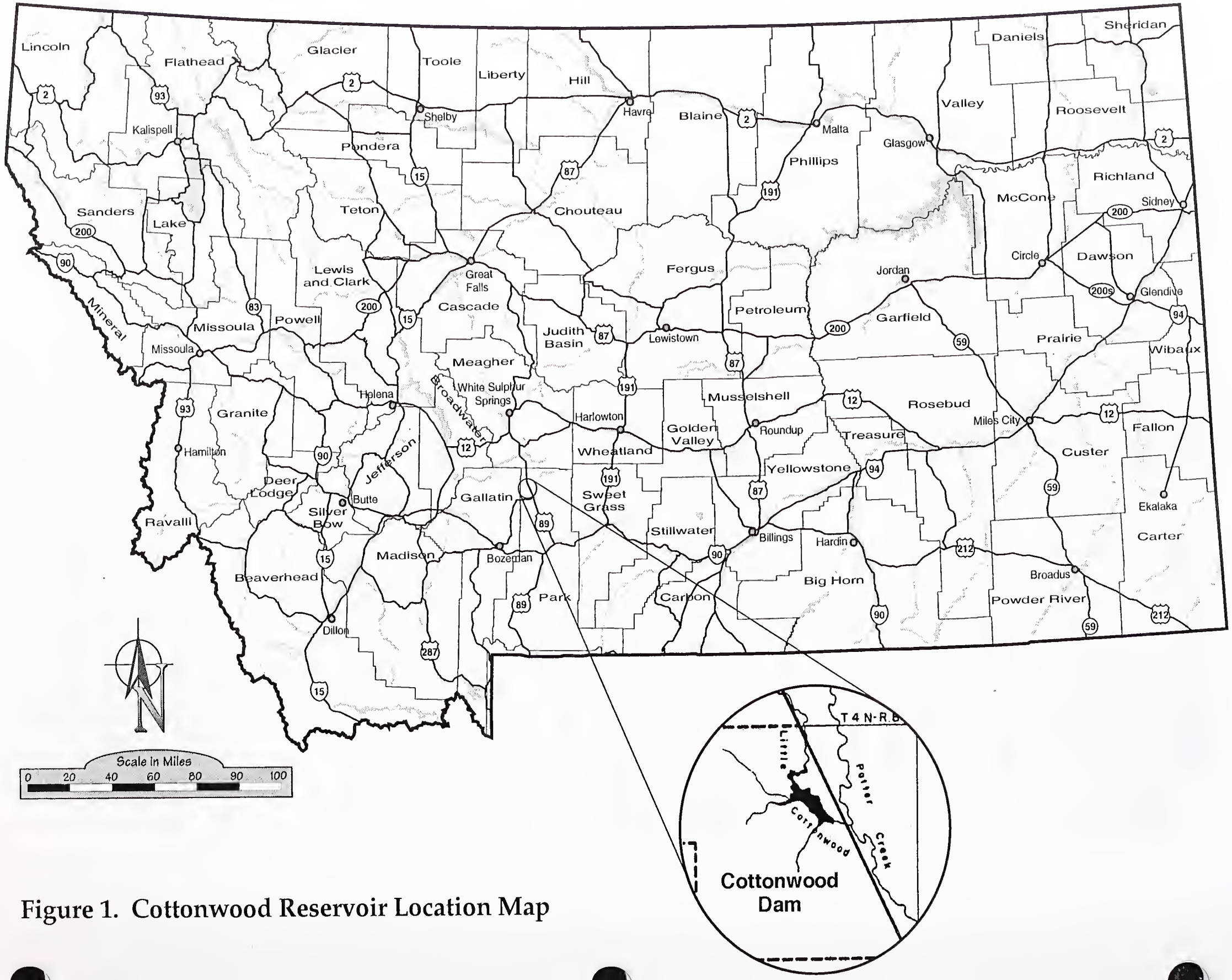

Figure 1. Cottonwood Reservoir Location Map

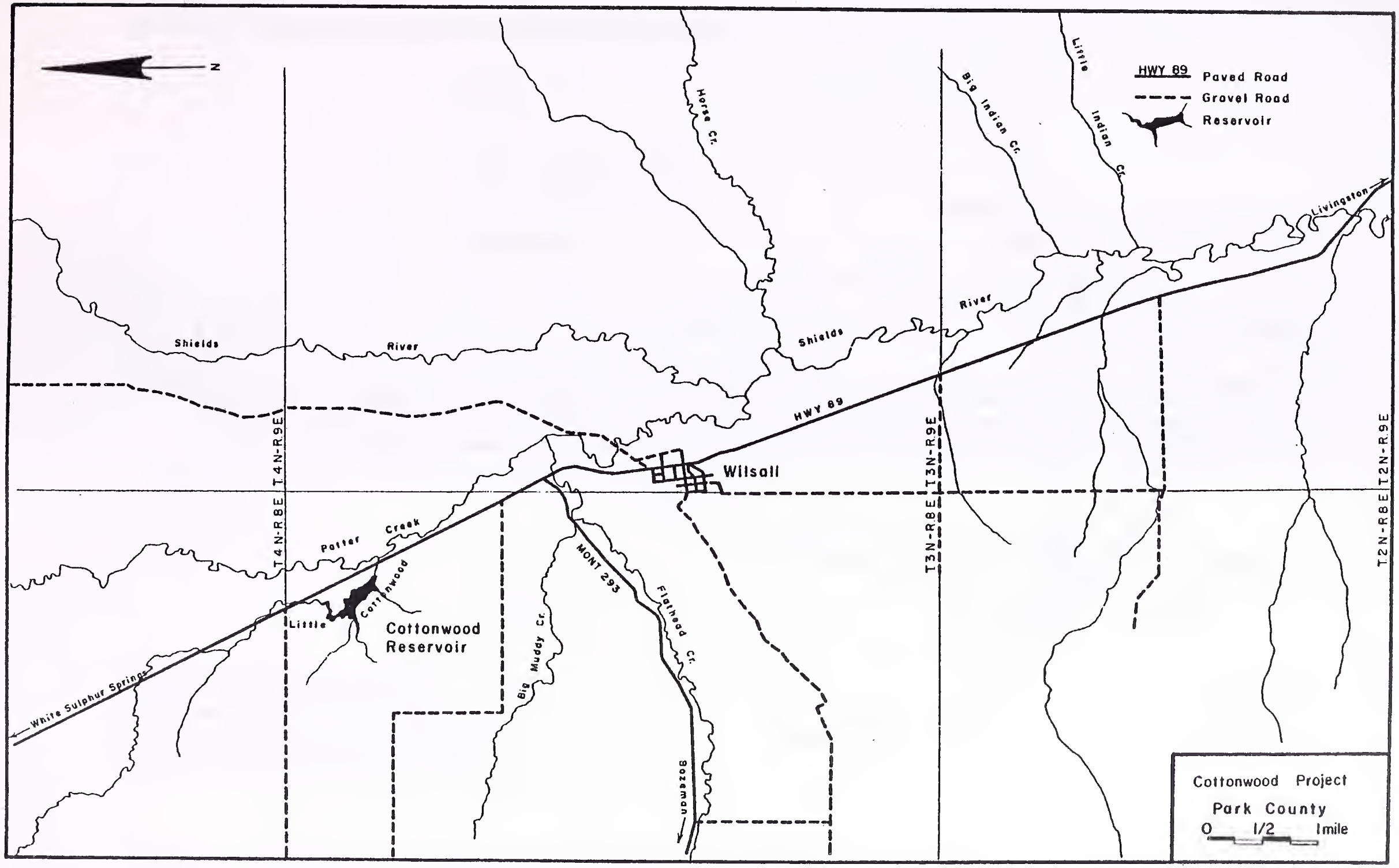

Figure 2. Cottonwood Project Map

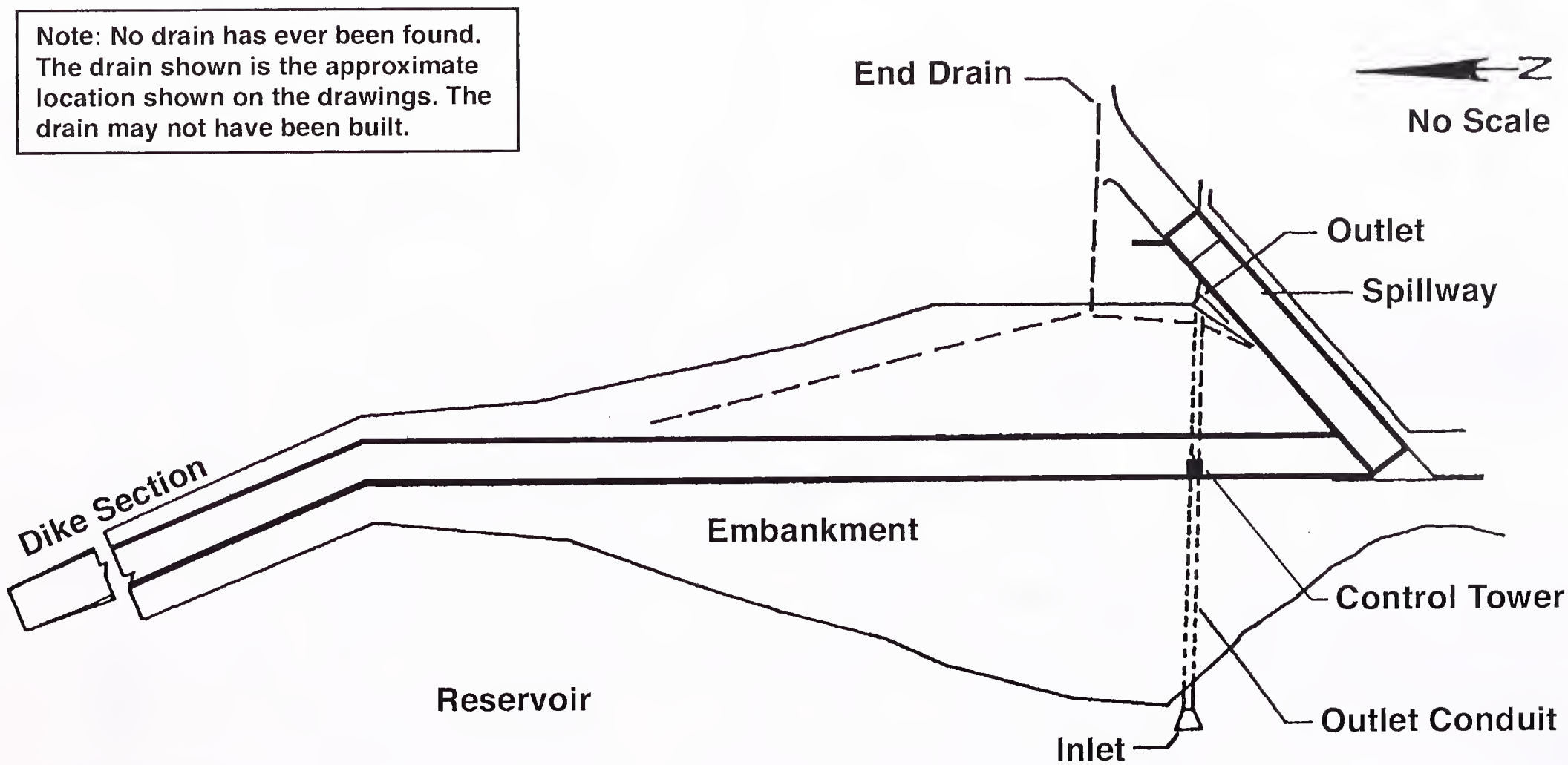

Figure 3. Cottonwood Dam General Layout Map

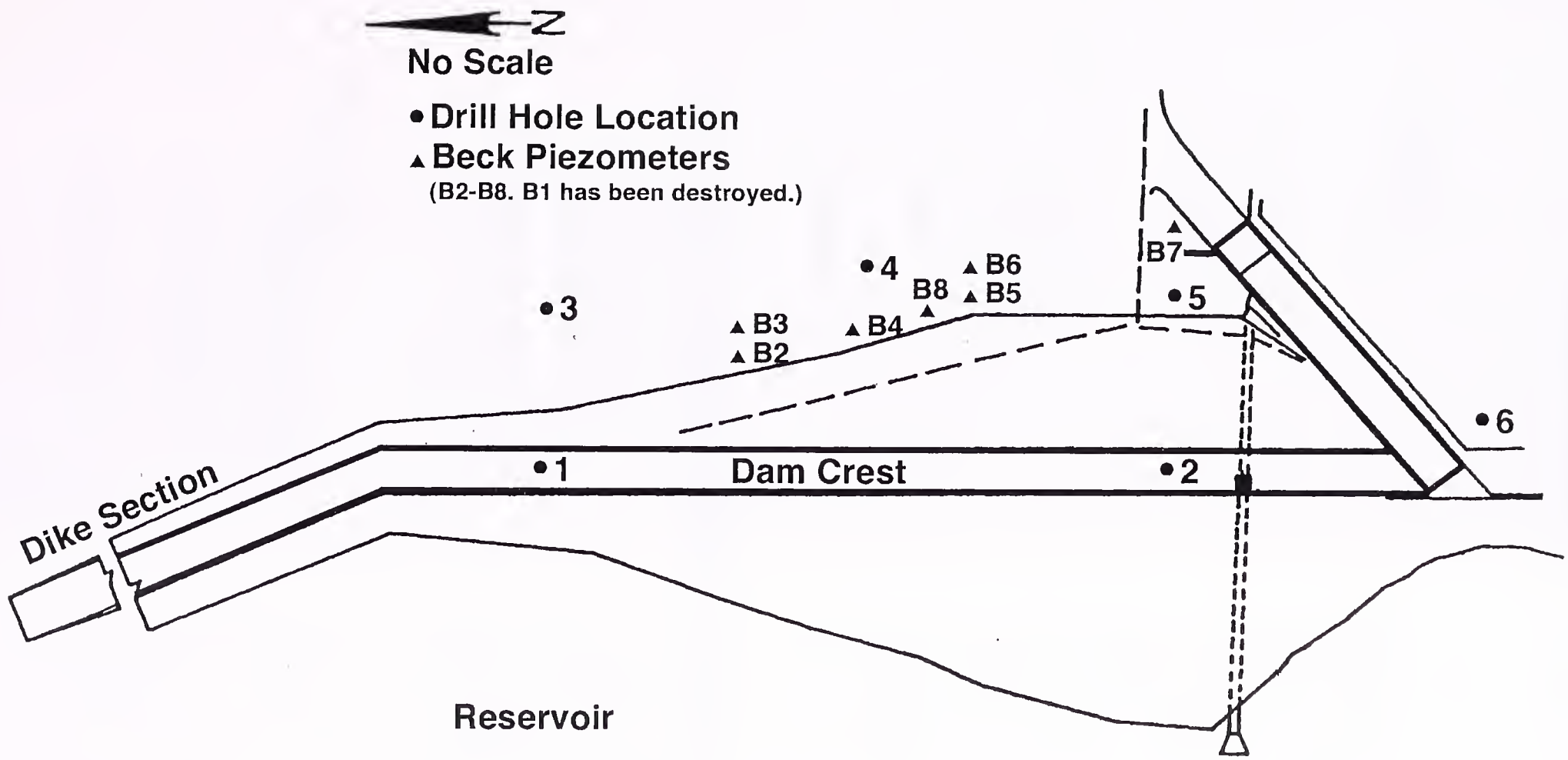

Figure 4. Cottonwood Dam Monitoring Wells Location

STATISTICAL INFORMATION

1. General

a. Owner	Montana Department of Natural Resources and Conservation (DNRC)
b. Operator	Shields Canal Company
c. Location	Sections 1, 2, 11, and 12, Township 3 North, Range 8 East
d. Latitude Longitude	46° 02' 00" 110° 40' 54"
e. County--State	Park--Montana
f. Watershed Location	Cottonwood Creek (tributary to Potter Creek)
g. Drainage Area	34 square miles

2. Principal Elevations (feet above mean sea level)

a. Minimum Dam Crest	5,108.7 feet
b. Normal Full Pool	5,102.5 feet
c. Guard Dike Crest	5,102.5 feet
d. Spillway Ogee Crest	5,100.5 feet
e. Outlet Design Invert	5,072.0 feet

3. Reservoir

a. Length of Maximum Pool (approximate)	0.9 mile
b. Maximum Reservoir Level of Record	5103.0 ft (est.)
c. Surface Area at Normal Pool	235 acres

4. Storage

a. Total Storage (pool at dam crest)	3,670 acre-feet
b. Active Storage (pool at guard dike crest)	1,905 acre-feet
c. Maximum Surcharge (from guard dike to dam crest)	1,765 acre-feet

5. Hydrology

a. Inflow Design Flood (HKM -- 1986)	14,200 cfs -- Probable Maximum Flood
b. Spillway Compliance Analysis For 0.62 LOL 1/2005 (Kraig McLeod)	2,660 cfs
c. 500-Year Flood	1,770 cfs
d. 100-Year Flood	1,120 cfs

6. Dam Embankment

a. Type	Zoned earthfill
b. Hydraulic Height	39 feet
c. Crest Length	610 feet (includes spillway -- 20 feet)
d. Crest Width	20-26 feet
e. Downstream Slope	1v on 2.0h
f. Upstream Slope	1v on 3.0h

7. Dike Embankment

a. Type	Earthfill
b. Hydraulic Height	8 feet
c. Crest Length	825 feet
d. Crest Width	10-18 feet
e. Downstream Slope	1v on 2.0h
f. Upstream Slope	1v on 4.0h

8. Spillway

a. Location	Right abutment
b. Type	Uncontrolled guard dike with an ogee crest
c. Width	Guard dike - 70 feet Ogee crest - 20 feet
d. Chute Width	20 feet
e. Maximum Capacity (pool at dam crest)	1,375 cfs

9. Outlet Works

a. Size	A single 36-inch diameter corrugated steel pipe, 10-gauge, double bituminous coated with paved invert.
b. Length	197 feet
c. Control	A single 36-inch diameter vertical slide gate located in a rectangular wet tower with control at dam crest
d. Capacity (pool at dam crest)	112 cfs
e. Trashrack	Yes

OPERATING PROCEDURES

The Shields Canal Company operates Cottonwood Dam to provide an adequate supply of irrigation water to meet contracts with the water users without exceeding safe storage or flow levels, and to insure safe operation of the project.

DAM OPERATOR

The responsibility for the daily operation of the dam and reservoir rests with the association and its dam operator. The dam operator is generally authorized to operate the reservoir to meet the association's goal of providing storage and regulation in support of agriculture. The dam operator's specific responsibilities are to:

1. Operate the mechanical features of the outlet works.
2. Coordinate filling of the reservoir and the release of water.
3. Notify the SWPB of unusual occurrences such as vandalism, impending flood, excessive seepage, problems with the outlet, or other unusual situations that may occur.
4. Perform various maintenance tasks.
5. Monitor weather conditions.
6. Monitor seepage.

Typically, the outgoing dam operator, association, and the SWPB train a new dam operator. The dam operator's training focuses on the mechanical operation of the gate, measurement of the storage level, measurement of the rate of water release, and record keeping.

The dam operator is normally available to observe the dam and perform operating functions weekly during the filling and irrigation season and monthly at other times of the year. Communication among the dam operator, the association, and the SWPB typically takes place by telephone. Although not routinely

available, during emergencies or unusual occurrences, radio communication may be established so that the dam operator can speak directly with county authorities and communicate indirectly with the SWPB (***see* Cottonwood Dam Action Emergency Plan**).

METHOD AND SCHEDULE OF OPERATION

For most the year, the outlet remains in a closed position. Any snowmelt or other runoff is stored in the reservoir until filled. Water in excess of the storage capacity is simply allowed to discharge over the spillway. According to the dam operator, the spillway spills about seven out of ten years. The date chosen for opening the outlet varies according to the needs of the irrigators, but it will be, generally, near the end of June or first half of July. The gate is typically set to release about 12 to 15 cfs when opened. Releases are then adjusted as needed according to stream conditions and the requirements of the water users. The capacity of the distribution canal limits useable releases to about 18 cfs. The gate is then typically closed before the first of September. The water may be released from May 1 through September 30. The typical total annual drawdown of the reservoir is estimated to be about 12 -15 feet.

Maximum Winter Storage. The maximum reservoir elevation for winter storage is 5,097.5 feet with 957 acre-feet of storage. This winter maximum helps prevent damage to the riprap and embankment from wind-driven waves and ice.

Minimum Winter Storage. The minimum reservoir elevation for winter storage is 5083.4 feet with 50 acre-feet of storage. This winter minimum helps prevent ice damage to the inlet structure for the outlet works.

SAFE DRAWDOWN

Because of the stability of Cottonwood Dam has not been thoroughly investigated relative to its structural stability, the SWPB recommends that drawdown rates should not exceed one foot per day.

GATE OPERATION

The maximum capacity of the outlet conduit with the reservoir at the dam crest is 112 cfs. The outlet works are to be used for controlling the releases of irrigation water and not for providing emergency relief.

The outlet gate is operated manually with a hand crank. The maximum the gate should be opened is 3 feet. Openings in excess of this amount may damage the gate, gate frame, gate stem or the gate-operating pedestal. The 3 feet of operation is measured on the exposed portion of the gate stem between the top of the pedestal and the bottom of the stop nut.

SPILLWAY

The spillway has a capacity of 1,375 cfs at the minimum dam crest elevation. The spillway-rating table is shown in Appendix A.

STORAGE DETERMINATION

Storage in the reservoir and the elevation of the reservoir surface are determined by taking a slope measurement. Measure in feet from the rebar pin located along the north side of the gate operating pedestal concrete pad to the water surface. The elevation of the reservoir surface and the storage can then be found using the Slope-Elevation-Storage Table in Appendix A.

If water is flowing over the guard dike in front of the spillway, the reservoir storage and elevation can be determined by measuring the depth of the water going over the guard dike. The elevation of the guard dike is 5,102.5 feet. Add the depth of the water going over the guard dike to 5,102.5 to find the elevation of the water surface. Once the reservoir surface elevation is determined, the reservoir storage is found using the Elevation/Storage Table (Table 2) in Appendix A.

WEATHER MONITORING

Weather conditions will be monitored by the dam operator through normal local weather forecasts and the National Weather Service.

If severe flooding is anticipated, the NWS Billings Office **(800-240-4596 or 406-652-2314)** should be contacted for information about the storm, such as the estimated storm intensity and duration, runoff duration (above base flow), and total flood volume of the storm in the Cottonwood Creek drainage.

INTERACTION WITH OTHER DAMS

The only dams located downstream of the Cottonwood Dam are irrigation diversion dams. The safety of these dams is not affected by the operation of Cottonwood Dam during either normal or emergency operations. Therefore, interaction with other dams is not a concern of the normal operation of Cottonwood Dam.

EMERGENCY

If it appears that Cottonwood Dam is about to breach, or during emergency operations, the dam operator will initiate the **Cottonwood Emergency Action Plan.**

INSPECTION AND MONITORING

The SWPB conducts annual inspections of the dam. Appendix B includes an example of a SWPB inspection report form. In addition to annual inspections, SWPB personnel will inspect the dam and reservoir during and after heavy runoff, severe rainstorms, and severe windstorms during high storage periods and after an earthquake.

STURCTURAL FEASTURES INSPECETION

Structural features include the dam embankment, dike, spillway and outlet works. The SWPB inspects these structures annually as part of its inspection program. Items to be checked or noted include, but are not limited to:

1. Outlet Works
   a. Any differential settlement or movement resulting in cracking of the conduit.
   b. Erosion of the seals or corrugated metal pipe by cavitation immediately downstream of the gates
   c. Major seepage of water into the conduit or emerging at spillway sidewall along side conduit
   d. Major deterioration of exposed concrete due to freeze/thaw cycles or sulfate reactions
   e. Operation of the gate
   f. Corrosion of any metal
   g. Proper lubrication of pedestal
   h. Unobstructed operation of the air vent
2. Embankments
   a. Erosion gullies in dam and dike faces.
   b. Damage from burrowing animals or vegetation.
   c. Displacement or loss of riprap protection.

d. Displacement of fill, sink holes, slumps etc.

e. Any seepage.

4. Spillway
   a. Cracking or displacement of the concrete floor, baffle blocks, and sidewalls.
   b. Seepage into, underneath or along the sides of spillway.
   c. Excessive sediment or debris at guard dike or ogee crest.
   d. Erosion, undermining, or unaccountable flow at bottom of spillway.
   e. General deterioration.
   f. Blockage of the approach or exit channel.

RIPRAP INSPECTION

The riprap on the upstream face of the dam should be at least 30 inches thick. Immediately after the occurrence of high water, the riprap will be inspected and additional riprap added if needed.

MONITORING WELLS

Three holes were drilled in May 1982. Two of these holes were destroyed when the spillway was rehabilitated in 1986. The remaining hole is located on the south side of the spillway.

Seven "Beck'" piezometers were installed by the SWPB along the toe of the dam in the left abutment in August 1997. An eighth "Beck'" piezometer was installed by the SWPB in April 1998. Currently seven piezometers remain.

Five holes were drilled in November 1999. Two of these were drilled along the top of the dam crest and the remaining three holes were drilled along the toe of the dam embankment. (See Figure 4.) Soil profiles of the drill holes and details as to how the wells were constructed are shown in Appendix D.

SEEPAGE

There is one seepage area at the toe of the dam and two seepage areas along the outlet channel downstream of the dam. Following is a summary of these seeps.

Left Abutment Toe Area. This seep area is located in the left abutment at the toe of the embankment. The seepage area is approximately 40 feet in diameter and produces no surface flow. The seep is evident based on the greenness and density of the vegetation, water-type grasses and sedges, and the soil is damp at times. This seep has been observed at all pool elevations.

Left Side Of The Outlet Channel. This seep is located on the left side of the outlet channel about 15 feet downstream of the end of the spillway. This seep produces a fairly constant clear flow from an area about 3-4 feet in diameter. This seep may be flow from the drain; however the specific location of the toe drain has not been confirmed. A pipe has been installed at this location to make collection and measuring of the flow easier. The flow varies from 0 to about 7 gallons per minute depending on the elevation of the reservoir pool.

Outlet Channel Downstream From The Dam. This seepage area is along the outlet channel about 250 feet below the end of the spillway. This seepage area exits on both sides of the channel, and is characterized by standing water and water-type plants. The seepage in this area may be passing through the weathered zones in the laminated sandstone bedrock of the left abutment. The seep varies from being damp to flowing less than a gallon per minute, and has been observed at all pool elevations.

SEEPAGE MONITORING

The monitoring wells and seepage areas at the dam are observed and monitored by the dam operator, DNRC Bozeman Regional Office, and SWPB during regular visits; and may be measured by the SWPB during annual inspections.

The instruments are generally measured once per month in March, April, July, August, September, and October; and twice per month in May and June. Measurements may be taken during the winter months (November, December, January, February) depending on weather conditions. The monitoring data is maintained by the SWPB in Helena.

MAINTENANCE

The association is responsible for routine maintenance of the project. The SWPB may identify items that need maintenance or repair during the annual report.

ROUTINE MAINTENANCE

To protect the dam embankment and dike and keep them in good order, the dam operator, during regular visits to the dam, will watch for and identify any potential maintenance requirements. As soon as a need is identified, the dam operator needs to schedule and perform the routine maintenance

Items that may need occasional attention include, but are not limited to:

1. *Lubrication of gate-operating mechanism.*
2. *Debris or sediment restricting the spillway inlet or the outlet works.* Accumulated debris that could affect the operation of these appurtenances should be removed at once, with all debris removed at least annually.
3. *Erosion gullies on embankment or dike.* Development of gullies should be checked immediately. Gullies should be filled, compacted and seeded. Particular attention will be paid to the abutment contact areas and the downstream face.
4. *Rodent damage.* The rodents will be removed or destroyed, and any burrows holes should be filled immediately.
5. *Upstream slope riprap.* The upstream face riprap will normally be observed annually, but may occasionally need repairs because of high water or wave action.
6. *Vegetative cover on downstream slopes and dike.* Good vegetative cover must be maintained, but large brush should be removed.
7. *Noxious weeds.* Noxious weeds on and around the dam embankment and around the reservoir should be sprayed at

8. *Clean spillway wall tops.* Spillway wall tops should be clear of any dirt. rocks, grass, brush, and overhanging vegetation.

9. *Repair joints and seal cracks in the spillway*

ANNUAL MAINTENANCE

The SWPB conducts annual inspections of Cottonwood Dam and reservoir. During these inspections, any items that require maintenance are identified and recorded. Items that may need annual maintenance include the spillway, outlet works, gate, riprap, monitoring wells, and the dike. Other routine items needing immediate attention, such as removing brush will be noted.

After the inspection, the SWPB sends the association a Dam Safety Inspection Report and a Maintenance Schedule Report. The reports identify items that need maintenance and provide a schedule of when the maintenance tasks need to be completed. The association is responsible for performing the maintenance items within the times specified.

The dam operator or association members may perform the maintenance tasks. However, major repairs will likely be handled by a contractor. The SWPB may assist in contracting for repairs and may supervise the repair work.

RECORK KEEPING

The SWPB maintains records, including photographs, of all inspections and maintenance requirements. These records also include seepage monitoring observations and monitoring well measurements. Anyone who wants to review these records may do so in the SWPB's office at the Department of Natural Resources and Conservation in Helena Montana.

The dam operator will keep records of the reservoir elevations, seepage observations, seepage measurements, and any unusual conditions. These records may be reviewed at the dam operator's house.

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APPENDICES

APPENDIX A

RATING CURVES AND TABLES

TABLE 1. SLOPE- ELEVATION-STORAGE TABLE

COTTONWOOD RESERVOIR

Table prepared by DNRC 8/27/1997.
Storage values based on 1952 original surveys of the reservoir.
The 0+00 pin is located on the north side of the operating gate concrete pad.

Top of Operating Gate Concrete Pad	5,109.0 feet
Dam Crest	5,108.7 feet
Guard Dike Crest Elevation	5,102.5 feet

DISTANCE feet	ELEVATION feet	STORAGE acre-feet	DISTANCE feet	ELEVATION feet	STORAGE acre-feet
0 Top Pin 1	5108.99	3,797	35	5099.49	1,284
1	5108.80	3,741	36	5099.19	1,229
2	5108.61	3,685	37	5098.89	1,175
3	5108.43	3,631	38	5098.60	1,125
4	5108.24	3,575	39	5098.30	1,072
5	5108.05	3,519	40	5098.00	1,020
6	5107.83	3,454	41	5097.65	976
7	5107.61	3,389	42	5097.31	933
8	5107.40	3,326	43	5096.96	890
9	5107.18	3,261	44	5096.62	849
10	5106.96	3,196	45	5096.27	807
11	5106.65	3,104	46	5095.91	765
12	5106.35	3,016	47	5095.55	728
13	5106.04	2,924	48	5095.18	689
14	5105.74	2,835	49	5094.82	654
15	5105.43	2,743	50	5094.46	621
16	5105.08	2,640	51	5094.30	607
17	5104.73	2,536	52	5094.14	593
18	5104.37	2,430	53	5093.97	577
19	5104.02	2,326	54	5093.81	563
20	5103.47	2,166	55	5093.65	549
21	5102.91	2,008	56	5093.26	513
22	5102.64	1,940	57	5092.87	481
23	5102.37	1,873	58	5092.47	453
24	5102.10	1,805	59	5092.08	426
25	5101.83	1,745	60	5091.69	398
26	5101.60	1,698	61	5091.52	386
27	5101.37	1,651	62	5091.36	375
28	5101.13	1,601	63	5091.19	363
29	5100.90	1,555	64	5091.03	352
30	5100.67	1,510	65	5090.86	342
31	5100.43	1,462	66	5090.36	313
32	5100.20	1,417	67	5089.87	285
33	5099.96	1,370	68	5089.37	256
34	5099.73	1,328			
DISTANCE	ELEVATION	STORAGE	DISTANCE	ELEVATION	STORAGE

2005

TABLE 2. ACTIVE STORAGE IN ACRE-FEET

COTTONWOOD RESERVOIR

ELEV	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
5,072	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
5,073	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
5,074	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
5,075	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
5,076	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9
5,077	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9
5,078	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8
5,079	8	8	9	9	9	9	10	10	10	11
5,080	11	11	12	12	13	13	14	14	15	15
5,081	16	17	18	19	20	21	22	23	24	25
5,082	26	28	29	31	32	34	36	37	39	40
5,083	42	44	46	48	50	52	55	57	59	61
5,084	63	66	68	71	74	76	79	82	85	87
5,085	90	93	96	99	102	105	107	110	113	116
5,086	119	122	125	129	132	135	138	141	145	148
5,087	151	155	159	162	166	170	174	178	181	185
5,088	189	194	198	203	207	212	217	221	226	230
5,089	235	241	246	252	258	263	269	275	281	286
5,090	292	298	304	309	315	321	327	333	338	344
5,091	350	357	364	371	378	385	392	399	406	413
5,092	420	427	434	441	448	455	462	469	476	483
5,093	490	499	508	517	526	535	544	553	562	571
5,094	580	589	598	607	616	625	634	643	652	661
5,095	670	680	691	701	712	722	733	743	754	764
5,096	775	787	799	811	823	835	847	859	871	883
5,097	895	907	920	932	945	957	970	982	995	1007
5,098	1020	1037	1055	1072	1090	1107	1125	1142	1160	1177
5,099	1195	1213	1231	1250	1268	1286	1304	1322	1341	1359
5,100	1377	1397	1417	1436	1456	1476	1496	1516	1535	1555
5,101	1575	1595	1616	1636	1657	1677	1698	1718	1739	1759
5,102	1780	1805	1830	1855	1880	1905	1930	1955	1980	2005
5,103	2030	2059	2088	2117	2146	2175	2204	2233	2262	2291
5,104	2,320									

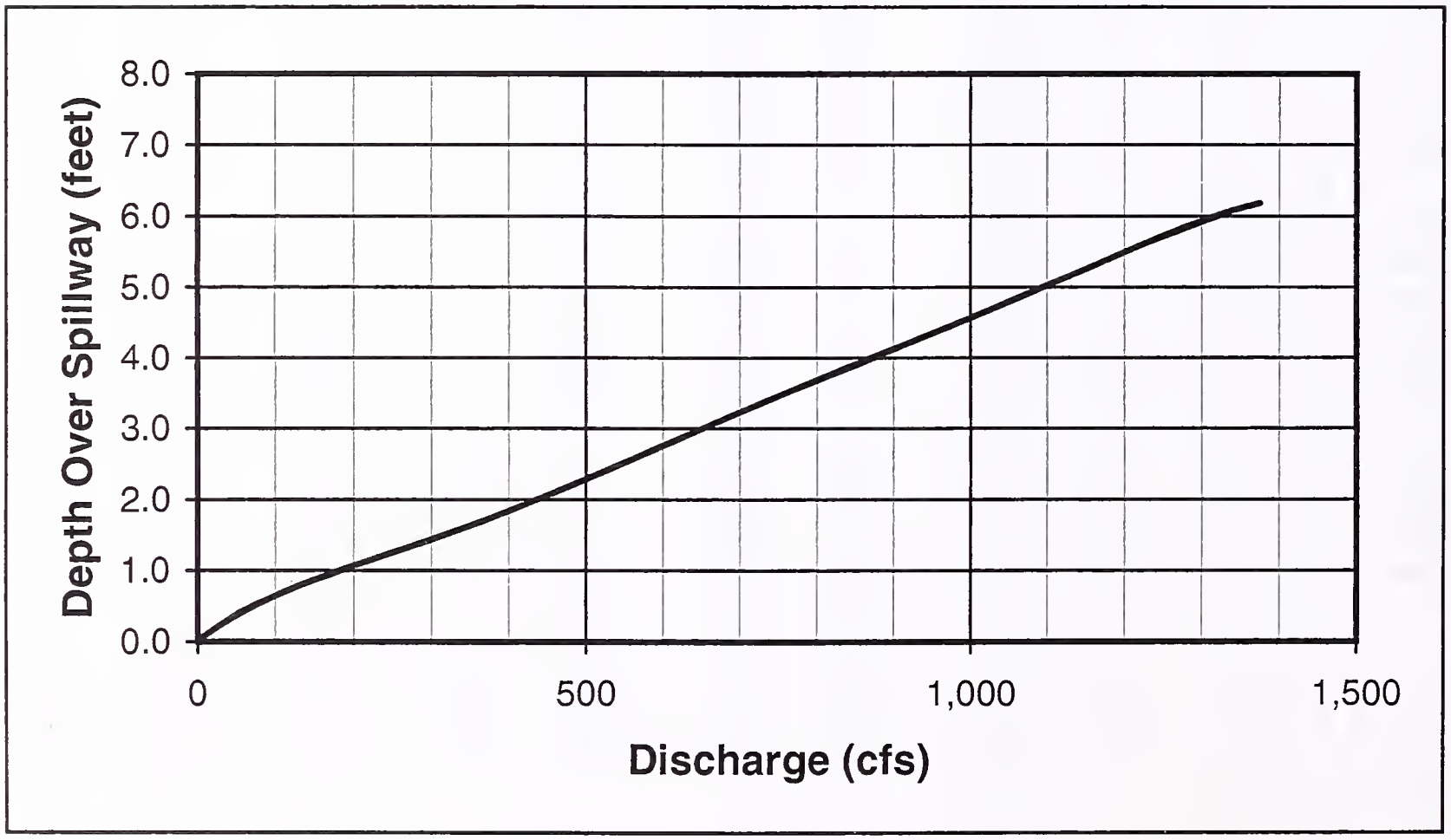
NOTE: Storage table based on 1952 original hand surveys of the reservoir.

Top of Concrete Tower Elevation --- 5,109.0 feet
Guard Dike Crest Elevation --- 5,102.5 feet

TABLE 3. SPILLWAY DISCHARGE

COTTONWOOD RESERVOIR

Depth Over Crest (feet)	Elevation (feet)	Discharge (cfs)
0.0	5,102.50	0
0.5	5,103.00	65
1.0	5,103.50	188
2.0	5,104.50	436
3.0	5,105.50	646
4.0	5,106.50	878
5.0	5,107.50	1,088
6.0	5,108.50	1,324
6.2	5,108.70	1,375



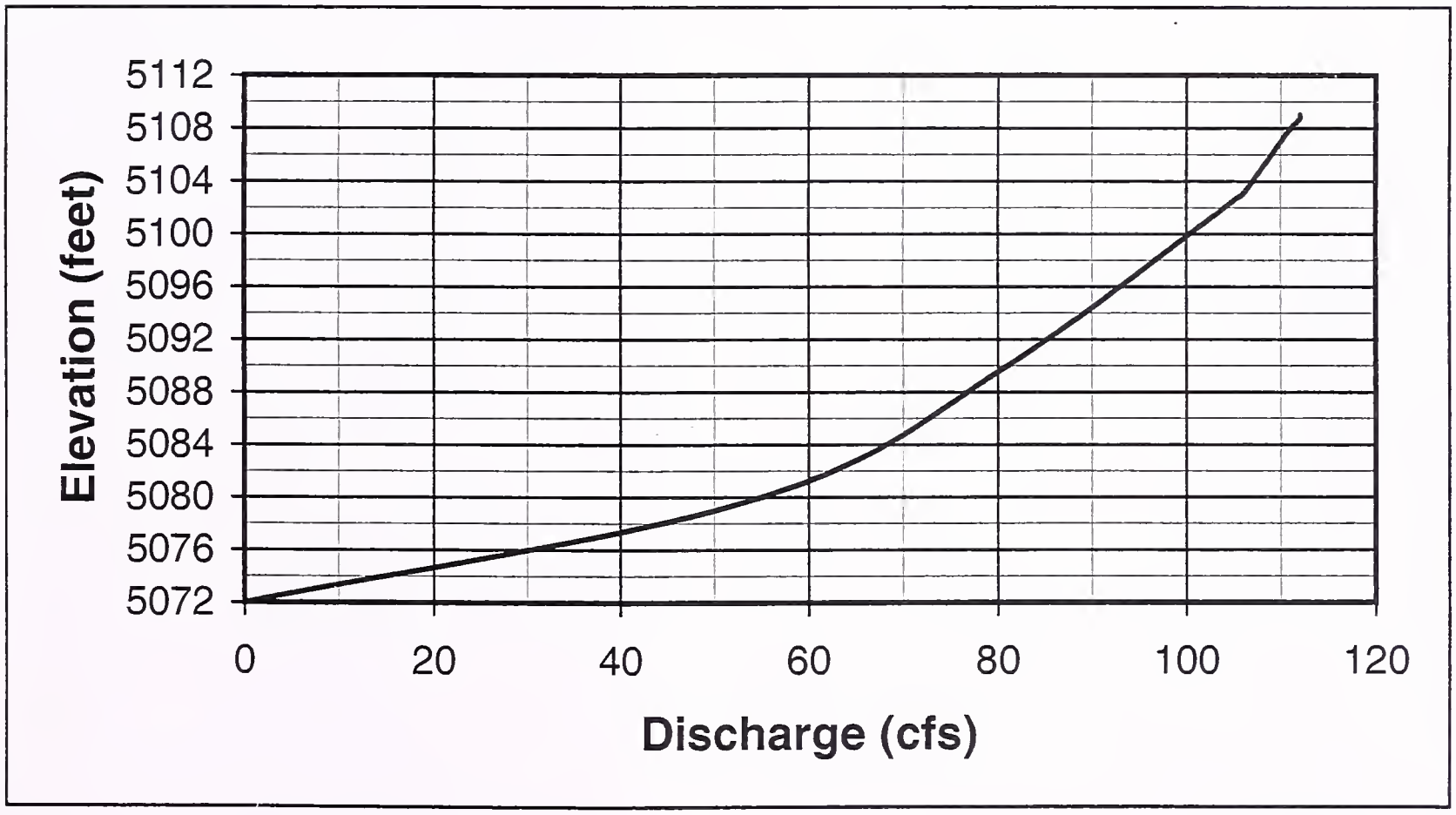
Note: Data based on spillway rehabilitation design by HKM (1986).

TABLE 4. OUTLET DISCHARGE

COTTONWOOD RESERVOIR

Reservoir Elevation (feet)	Discharge (cfs)	Comment
5072	0	
5080	55	
5090	81	
5102.5	105	Guard Dike Crest
5103	106	
5104	107	
5105	108	
5106	109	
5107	110	
5108	111	
5108.74	112	Minimum Dam Crest
5109	112	

Note: Discharge assumes operating gate is completely open.



Note: Data from the Corps of Engineers Phase 1 Inspection Report (1981).

APPENDIX B

INSPECTION REPORT FORM

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
DAM SAFETY INSPECTION REPORT

NAME OF DAM
DATE INSPECTED

INVENTORY NO. _____ OWNER _____
HAZARD CATEGORY _____ OPERATOR _____
TYPE OF DAM _____ STREAM _____
YEAR BUILT _____ DRAINAGE AREA _____

Reservoir Storage Status

	Water Surface Elevation (feet)	Storage (acre-feet)
At time of inspection	_____	_____
At spillway crest	_____	_____
At min. dam crest elevation	_____	_____

ITEM	YES	NO	REMARKS

1. EMBANKMENT

A. Crest -- Height= Length= Width=

(1) Any visual settlements?			
(2) Any misalignments?			
(3) Any cracking?			
(4) Any traffic damage?			
(5) Other?			

ITEM	YES	NO	REMARKS

1. EMBANKMENT (continued)

B. Upstream Face -- Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Is riprap protection adequate?			
(5) Any stone deterioration?			
(6) Any visual settlement, slumps, sloughing, depressions or bulges?			
(7) Adequate grass cover?			
(8) Debris on the dam face?			
(9) Other?			

C. Downstream Face--Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Any visual settlement, slumps, sloughing, depressions or bulges?			
(5) Is the toe drain dry?			
(6) Are the relief wells flowing?			
(7) Any boils at the toe?			
(8) Any seepage areas?			
(9) Any traffic or animal damage?			
(10) Any burrowing animals?			
(11) Adequate grass cover?			
(12) Other?			

D. Amount and Type of Vegetation on the Dam

.

ITEM	YES	NO	REMARKS

2. ABUTMENT CONTACTS

A) Any erosion?			
B) Any visual differential movement?			
C) Any cracks?			
D) Any seepage present?			
E) Other?			

3. OUTLET WORKS

A. Intake Structure -- Size=

(1) Any settlement?			
(2) Any tilting?			
(3) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(4) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(5) Metal appurtenances:			
a. Any corrosion present?			
b. Any breakage present?			
(6) Trash rack?			
a. Condition?			
b. Anchor system secure?			
(7) Other?			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

B. Conduit -- Type = Size =

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Is the conduit metal?			
a. Any corrosion present?			
b. Protective coatings adequate?			
(4) Is the conduit misaligned?			
(5) Any calcium deposits?			
(6) Other?			

C. Gates and Tower

(1) Gates:			
a. Size: Operating: Emergency: b. Type: Operating: Emergency:			
(2) Controls operational?			
(3) Controls lubricated?			
(4) Operational problems?			
(5) Leakage around gates?			
(6) Condition of gate seals?			
(7) Any cavitation damage? If so, describe?			
(8) Describe air vent-size and condition.			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

C. Gates and Tower (continued)

(9) Is there a jet pump?			
a. Is it operational?			
b. Leakage?			
(10) Is the tower dry? _____ wet?			
(11) Any seepage in the tower?			
(12) Condition of the tower?			
(13) Any safety problems?			
(14) Ladder in good condition?			
(15) Condition of the gatehouse?			
(16) Emergency plan completed for the dam?			
a. Posted in the gatehouse?			
(17) Other?			

D. Stilling Basin

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Do energy dissipaters show:			
a. Signs of deterioration?			
b. Are they covered with debris?			
(4) Other?			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

E. Downstream Channel

(1) Is the channel:			
a. Eroding or backcutting?			
b. Sloughing?			
c. Obstructed?			
(2) Is released water:			
a. Undercutting the outlet?			
b. Eroding the embankment?			
(3) Other?			

4. SPILLWAY

A. Description

(1) Location?			
(2) Type of Spillway?			
(3) Size of Spillway?			
(4) Spillway lining?			
(5) Is there a weir?			
(6) Is the spillway in good condition?			
(7) Any drains?			
a. Describe the condition of drains.			

B. Does spillway show:

(1) Any cracking concrete?			
(2) Any spalling concrete?			
(3) Any exposed reinforcement in the concrete?			
(4) Any erosion?			

ITEM	YES	NO	REMARKS

4. SPILLWAY (continued)

4. B. Does spillway show: (continued)

(5) Any slope sloughing?			
(6) Any obstructions?			
(7) Displacement or offset joints?			
(8) Loss of joint material?			
(9) Leakage at the joints?			
(10) Other?			

C. Do the energy dissipaters show:

(1) Signs of deterioration?			
(2) Any cracking?			
(3) Any spalling?			
(4) Any exposed reinforcement?			
(5) Are they covered with debris?			
(6) Other?			

D. Has release water:

(1) Eroded the embankment?			
(2) Undercut the outlet?			
(3) Eroded the downstream channel?			
(4) Other?			

E. Emergency Spillway

(1) Is there an emergency spillway?			(If YES, describe)

ITEM	YES	NO	REMARKS

5. RESERVOIR CONTROL

A) Recent upstream development?			
B) Recent downstream development?			
C) Slides in reservoir area?			
D) Change in reservoir operation?			
E) Large impoundment upstream?			
F) Any debris in the reservoir?			
G) Other?			

6. INSTRUMENTATION

A) List type(s) of instrumentation:			
B) In good condition?			
C) Read periodically?			
D) Is data available?			
E) Include all data gathered since last report.			

7. DOWNSTREAM CONDITION

A. Downstream Land Use.

This dam was inspected by:

Additional comments and recommendations.

APPENDIX C

O&M MANUAL DISTRIBUTION LIST

COTTONWOOD DAM O&M DISTRIBUTION LIST

	Number Of Copies
1. SWPB Kevin Smith Rob Kingery Dirk Roberts (2) Bob Arrington Dolores Eustice	6
2. DNRC Information Services Section	1
3. DNRC Regional Office Scott Compton	1
4. DNRC Dam Safety	1
5. Water Users Alan Johnstone -- President Les Arthun – Secretary and Dam Operator Ken Artun -- Director	3
6. State Library -- Attn: Roberta Gebhardt	4
7. Extra	2
TOTAL	18

APPENDIX D

MONITORING WELL LOGS

BECK PIEZOMETER TABLE

Piezometer Table

Piez #1 Total Length = 10.00' Stick-up = 1,96' Total in ground = 8.04'
Elev = 5065.28'
Note: This piezometer was destroyed in 1999.

Piex #2 Total Length = 5.00' Stick-up = 1.35' Total in ground = 3.65'
Elev = 5058.61'

Piez #3 Total Length = 10.55' Stick-up = 1.60' Total in ground = 8.95'
Elev = 5059.12'

Piez #4 Total Length = 10.25' Stick-up = 2.20' Total in ground = 8.05'
Elev = 5054.95'

Piez #5 Total Length = 10.22' Stick-up = 1.60' Total in ground = 8.62'
Elev = 5054.11'

Piez #6 Total Length = 5.00' Stick-up = 1.10' Total in ground = 3.90'
Elev = 5053.48'

Piez #7 Total Length = 10.30' Stick-up = 1.10' Total in ground = 9.20'
Elev = 5050.61'

Piez #8 Total Length = 10.64' Stick-up = 1.65' Total in ground = 8.65'
Elev = 5055.02'

SOIL LOG OF BOREHOLE NO: DH1

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: COTTONWOOD	DRILL RIG	: Strata Star 15
DATE STARTED	: 11/18/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/18/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 5109.3	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Field Blow Counts	Adjusted Blow Count (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	5109		0 to 2 9 SANDY LEAN CLAY with minimal (<10%) gravel pebbles and fragments, dark brown, slightly moist, medium plasticity									
5	5104	X				SS	5 7 10	27	10.8/18	60%		
10	5099	X				SL	14 9 8	18	4/18	22%		Hit a rock, broke shoe in sampler Rock blocked sample
15	5094	X		CL		ST						15 to 17' % Finer #200 = 66% m = 20.9% LL=38% PL=17% PI=21% Dry Unit Weight = 107.2 pcf Moist Unit Weight = 129.6 pcf Fine content varies from 66 to 76%
20	5089	X X				SS SS	3 2 5 3 5 5	6 10	15.6/18 18/18	87% 100%		21.5 ' Estimating embankment foundation contact
25	5084	X				SL	3 5 5	9	16.8/18	93%		25.5 to 26' % Finer #200 = 77% m = 24.6 Dry Unit Weight = 85.5 pcf Moist Unit Weight = 106.6 pcf
30				SS						95%		29' Bedrock contact Stopped augering, begin coring Cored 1' (29 to 30') RQD = 33% poor

Hollow Stem Auger 4 1/2" ID Core Barrel HQ3
Hammer 140 lbs 30" drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"

03-29-2005 ...ATER_RT\WRB-STAF\Bob A\Well Logs\Cottonwood Logs\Cottonwood DH-1 Soil.bor

SOIL LOG OF BOREHOLE NO: DH1

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: COTTONWOOD	DRILL RIG	: Strata Star 15
DATE STARTED	: 11/18/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/18/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 5109.3	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Field Blow Counts	Adjusted Blow Count (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
30	5079		29 to 45 SANDSTONE, greenish gray to dark gray, extremely fractured, many fractures appear water bearing, minor calcite along fractures							92%		Cored 5' (30 to 35') Appears entire reach carries water RQD = 45% poor
			29 to 32.5 sandstone, as above									
35	5074		32.5 to 33.8 sandstone, more clays, softer, olive green	SS						91%		Cored 10' (35 to 45') Appear many fractures of reach carry water RQD = 32%
			33.8 to 39.1 light brown sandstone, finer grained									
40	5069		39.1 to 41.5 greenish gray sandstone, strongly fractured									Refer to digital photos in project files
			41.5 to 45 dark greenish gray sandstone, more competent									
45	5064		45 BOTTOM OF HOLE									
50	5059											
55	5054											
60												

Hollow Stem Auger 4 1/2" ID Core Barrel HQ3
Hammer 140 lbs 30" drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"

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WELL COMPLETION LOG NO: DH1

MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Cottonwood	DRILL RIG	: Strata Star 15
DATE STARTED	: 11/18/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/18/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

Depth In Feet | Surf. Elev. 5109.3

0 – 5109
5 – 5104
10 – 5099
15 – 5094
20 – 5089
25 – 5084
30 – 5079
35 – 5074
40 – 5069
45 – 5064
50

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 11/18/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Bob Arrington

STANDPIPE

Material	: PVC pipe
Diameter	: 1 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 1 inch
Length	: 5 feet
Opening	: .02 inch

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 7 inch
Length	: 5 feet

NOTES:

Surface Elev: 5109.34 feet

DH1A TOP Elev: 5109.8 feet

DH1B TOP Elev: 5109.61 feet

Top of Cover Elev: 5110.0 feet (estimate)

Northing: 10296.86

Easting: 9997.14

Surveyed By: Mike Lesnik

Date Surveyed: 1/25/2000

DESCRIPTION

0 to 5 SAND

5 to 10 BENTONITE

10 to 18 SAND

12 to 17 SCREEN FOR DH1B

18 to 27 BENTONITE

21.5 embankment/foundation contact

27 to 37 SAND

29 bedrock contact

31 to 36 SCREEN FOR DH1A

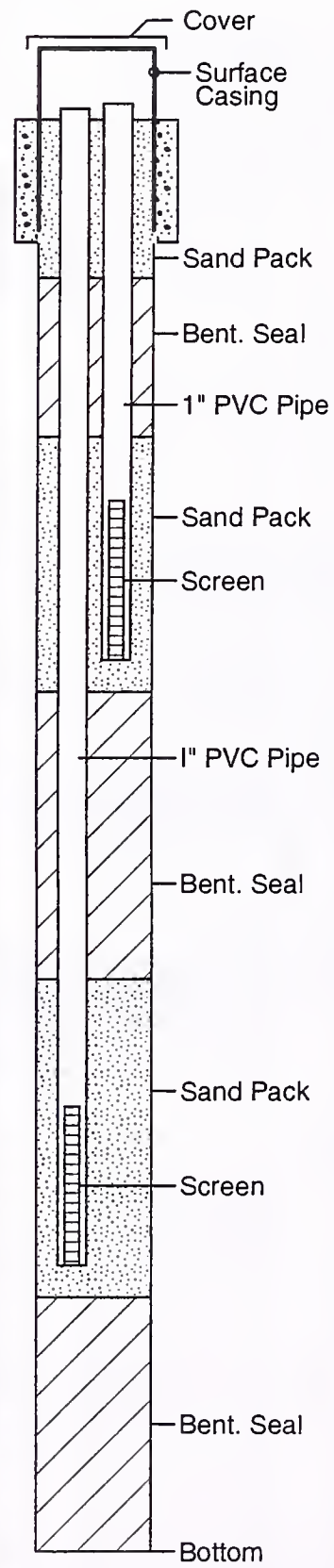
37 to 45 BENTONITE

45 BOTTOM OF HOLE

Depth In Feet

0
5
10
15
20
25
30
35
40
45
50

Well1: DH-1A
Well2: DH-1B



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SOIL LOG OF BOREHOLE NO: DH2

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Cottonwood	DRILL RIG	: Strata Star 15
DATE STARTED	: 11/15/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/17/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 5108.9	Sample	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	5108		0 to 20' SANDY LEAN CLAY with minimal (<10%) gravel pebbles and fragments, dark brown, slightly moist, medium plasticity									
5	5103											
10	5098	X		CL		SS	4 6 12	20	13.2/18	73%		
15	5093	X				SL	9 8 9	16	13.2/18	73%		15.5 to 16.0' % Finer #200 = 50% m = 18.1% dry unit weight = 112.7 pcf moist unit weight = 133.1 pcf
20	5088	X	20 to 45' CLAYEY SAND with some gravel pebbles and fragments, brown, slightly moist, medium plasticity			ST			20/22	91%		20.0 to 22.0' % Finer #200 = 44% m = 18.1% dry unit weight = 112.7 pcf moist unit weight = 133.1 pcf LL=39% PL=18% PI= 21% cu test: c=2.6 phi=10.0 Effective c=0.98 phi=32.2
25	5083	X		SC		SS	4 5 4	8	18/18	100%		
30	5078	X	30.5 to 37.5' 25% small gravels of sandstone			SL	6 8 11	15	16.8/18	93%		30.5 to 31.0' % Finer #200 = 62% m = 17.8 % dry unit weight = 107.8 pcf moist unit weight = 127.0 pcf
35												

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30" drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner SPoon OD 2.5" ID 2.0"

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SOIL LOG OF BOREHOLE NO: DH2

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Cottonwood	DRILL RIG	: Strata Star 15
DATE STARTED	: 11/15/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/17/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 5108.9	Sample	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
35												
	5073	☒	35 to 45' CLAYEY SAND 35.5 to 36.5 grass root fragments 38.5 to 39.5 50 to 60% sandstone fragments, rounded river cobbles, wet, loose 40 to 45 augering easy	SC		SS	3 4 9 13	10	19.2/24	80%		36' Estimated embankment foundation contact 37.5 to 38.0' % Finer #200 = 45.7%
40	5068											
45	5063	☒	45 to 64' SANDSTONE, light gray to gray, medium grained	SS		SS	12 50		10/10	100%		45' Bedrock contact Stopped augering, begin coring
		—	45 to 50.5' weathered, extremely fractured, entire reach appears water bearing							45%		45 to 50.5' Cored 5.5 Recovered 2.5' RQD = .07% very poor
50	5058	—	50.5 to 55' contains rounded pebble conglomerate rocks, very fractured, several fractures appear water bearing							89%		50.5 to 55' Cored 4.5' Recovered 4' RQD = 60% fair
55	5053	—	55 to 64' fairly competent, contains some conglomerate rock, several fractures appear water bearing 56 to 57.5' rounder pebble conglomerate							100%		55 to 64' Cored 9' Recoverd 9' RQD = 85% good
60	5048		61 to 62.8 conglomerate, rounded igneous pebbles up to 1.5" diameter Minor calcite along fractures in all of above.									Refer to digital photos in project files
65	5043		64' BOTTOM OF HOLE									
70												

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30" drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner SPoon OD 2.5" ID 2.0"

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WELL COMPLETION LOG NO: DH2

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Cottonwood	DRILL RIG	: Strata Star 15
DATE STARTED	: 11/15/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/17/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

Depth In Feet | Surf. Elev. 5108.9

Well Construction Information

WELL CONSTRUCTION

Date Compl. : 11/17/1999
Hole Diameter : 8 inch
DNRC Rep. : Bob Arrington

STANDPIPE

Material : PVC pipe
Diameter : 1 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN

Material : PVC pipe
Diameter : 1 inch
Length : 5 feet
Opening : .02 inch

SAND PACK

Material : Colorado Silica 10/20

ANNULUS

Material : 3/8 inch Bentonite

WELL COVER

Diameter : 7 inch
Length : 5 feet

NOTES:

Surface Elev: 5108.90 feet

DH2A TOP Elev: 5109.25 feet

DH2B TOP Elev: 5109.09 feet

Top of Cover Elev: 5109.5 feet (estimate)

Northing: 10125.14

Easting: 9995.13

Surveyed By: Mike Lesnik

Date Surveyed: 1/25/2000

DESCRIPTION

0 to 5 SAND

5 to 19 BENTONITE

19 to 31 SAND

24 to 29 SCREEN FOR DH2B

31 to 41 BENTONITE

36 embankment/foundation contact

41 to 52 SAND

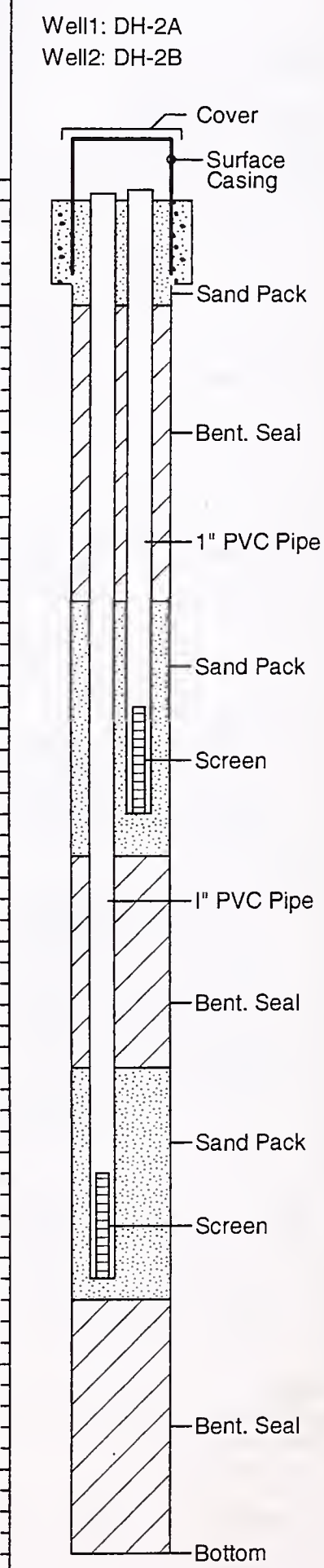
45 bedrock contact

46 to 51 SCREEN FOR DH2A

52 to 64 BENTONITE

64 BOTTOM OF HOLE

Depth In Feet



03-29-2005 G:\WATER_RT\WRB-STAF\Bob A\Well Logs\Cottonwood Logs\Cottonwood DH-2 WC.bor

SOIL LOG OF BOREHOLE NO: DH3

MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Cottonwood	DRILL RIG	: Track B53
DATE STARTED	: 11/15/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/16/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Tim Kuehn
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 5092.2	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	5092		0 to 14.5' SANDY LEAN CLAY with minimal (<15%) gravel, brown to dark brown, slightly moist, medium plasticity									
5	5087	☒	5 to 6.5' sandy gravel	CL		SL	8 12 20	41	14/18	78%		
10	5082	☒				SS	8 17 41	33				
15	5077		14.5 to 33' SANDSTONE, fine grained, gray									14.5' Bedrock contact Stopped augering, begin coring
			14 to 17' greenish gray, weathered, extremely fractured, high clay content							100%		14.5 to 19.5' Cored 5' Recovered 5' RQD = 33% poor
20	5072		17 to 19.5' reddish brown gray, competent rock							86%		19.5 to 23' Cored 3.5' Recovered 3' RQD = 24% very poor
			19.5 to 23.5 reddish brown gray, fairly competent, fractures occur 2" to 5" spacing	SS						90%		23 to 33' Cored 10' Recovered 9' RQD = 37% poor
25	5067		23.5 to 26' greenish gray, weathered, fractures, increased amount of clay particles in fractures									
30	5062		26 to 33 greenish gray to medium gray, competent rock									Refer to diigtal photos in project files.
			Minor calcite along fractures in all of above.									
35			33 BOTTOM OF HOLE									

Hollow Stem Auger 4 1/2 " ID
Core Barrel HQ3
Hammer 140 lbs 30" drop free-fall hoist
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"

03-29-2005 ...WATER_RT\WRB-STAF\Bob A\Well Logs\Cottonwood Logs\Cottonwood DH-3 Soil.bor

WELL COMPLETION LOG NO: DH3

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Cottonwood	DRILL RIG	: Track B53
DATE STARTED	: 11/15/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/16/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Tim Kuehn
DRILLER	:	APPROVED BY	: Kevin Smith

Depth In Feet | Surf. Elev. 5092.2

0 – 5092
5 – 5087
10 – 5082
15 – 5077
20 – 5072
25 – 5067
30 – 5062
35

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 11/16/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Tim Kuehn

STANDPIPE

Material	: PVC pipe
Diameter	: 1 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 1 inch
Length	: 5 feet
Opening	: .02 inch

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 7 inch
Length	: 5 feet

NOTES:

Surface Elev: 5092.20 feet

DH3A TOP Elev: 5092.46 feet

DH3B TOP Elev: 5092.22 feet

Top of Cover Elev: 5092.7 feet (estimate)

Northing: 10304.78

Easting: 10053.45

Surveyed By: Mike Lesnik

Date Surveyed: 1/25/2000

DESCRIPTION

0 to 5 SAND

5 to 7 BENTONITE

7 to 14 SAND

8 to 13 SCREEN FOR DH3B

14 to 22 BENTONITE

14.5 bedrock contact

22 to 33 SAND

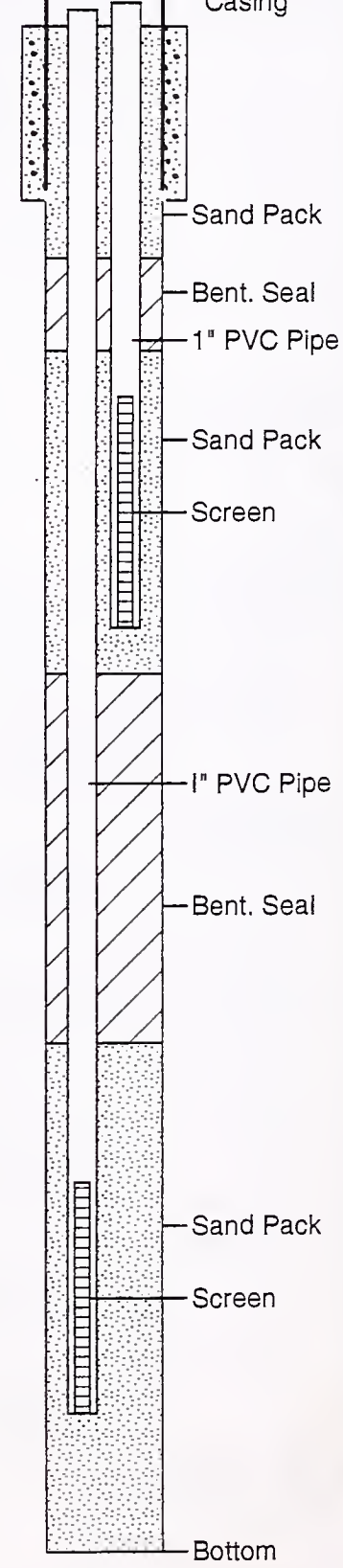
25 to 30 SCREEN FOR DH3A

33 BOTTOM OF HOLE

Depth In Feet

0
5
10
15
20
25
30
35

Well1: DH-3A
Well2: DH-3B



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SOIL LOG OF BOREHOLE NO: DH4

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Cottonwood	DRILL RIG	: Track B53
DATE STARTED	: 11/17/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/18/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Jim Beck
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 5084.4	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	5084		0 to 10' SANDY LEAN CLAY with minimal (<15%) gravel, brown to dark brown to gray, slightly moist									
5	5079	☒	6 to 7.5' wet zone	CL		SS	3 7 14	27	14.4/18	80%		
10	5074	☒	10 to 16' SILTSTONE, weathered, gray to gray green, hard, dry, clayey silt	SS		SL	23 50		11/18	61%		10' Bedrock contact 10 to 10.4' % Finer #200 = 91.2%
15	5069	☒				SS	32 50		8.5/18	47%		15' Stop augering, begin coring 15 to 20' Cored 5' Recovered 4.5' RQD = 72%
			16 to 33.5' SANDSTONE, gray to redish brown gray							90%		
20	5064		16 to 23.5' approximately 2 fractures per foot, all fractures appear water bearing, minor calcite along fractures							91%		20 to 23.5' Cored 3.5' Recovered 3.2' RQD = 31%
25	5059		23.5' to 33.5 less friable than above, gray, competent rock, probably transition from erosion surface to hard bedrock.	SS						100%		23.5 to 28.5' Cored 5' Recovered 5' RQD = 92%
										100%		28.5 to 33.5' Cored 5' Recovered 5' RQD = 88%
30	5054											Refer to digital photos in project files.
35			33.5' BOTTOM OF HOLE									

Hollow Stem Auger 4 1/2"
Core Barrel HQ3
Hammer 140 lbs 30" drop free-fall hoist
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"

03-29-2005 ...TER_RTWRB-STAF\Bob A\Well Logs\Cottonwood Logs\Cottonwood DH-4 Soil.bor

WELL COMPLETION LOG NO: DH4

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Cottonwood	DRILL RIG	: Track B53
DATE STARTED	: 11/17/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/18/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Jim Beck
DRILLER	:	APPROVED BY	: Kevin Smith

Depth In Feet | Surf. Elev. 5084.4

0 – 5084; 5 – 5079; 10 – 5074; 15 – 5069; 20 – 5064; 25 – 5059; 30 – 5054; 35

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 11/18/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Jim Beck

STANDPIPE

Material	: PVC pipe
Diameter	: 1 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 1 inch
Length	: 5 feet
Opening	: .02 inch

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 7 inch
Length	: 5 feet

NOTES:

Surface Elev: 5084.39 feet

DH4A TOP Elev: 5084.46 feet

DH4B TOP Elev: 5084.34 feet

Top of Cover Elev: 5084.7 feet (estimate)

Northing: 10238.23

Easting: 10064.43

Surveyed By: Mike Lesnik

Date Surveyed: 1/25/2000

DESCRIPTION

0 to 4 SAND

4 to 5.5 BENTONITE

5.5 to 14 SAND

10 bedrock contact

8 to 13 SCREEN FOR DH4B

14 to 18 BENTONITE

18 to 28 SAND

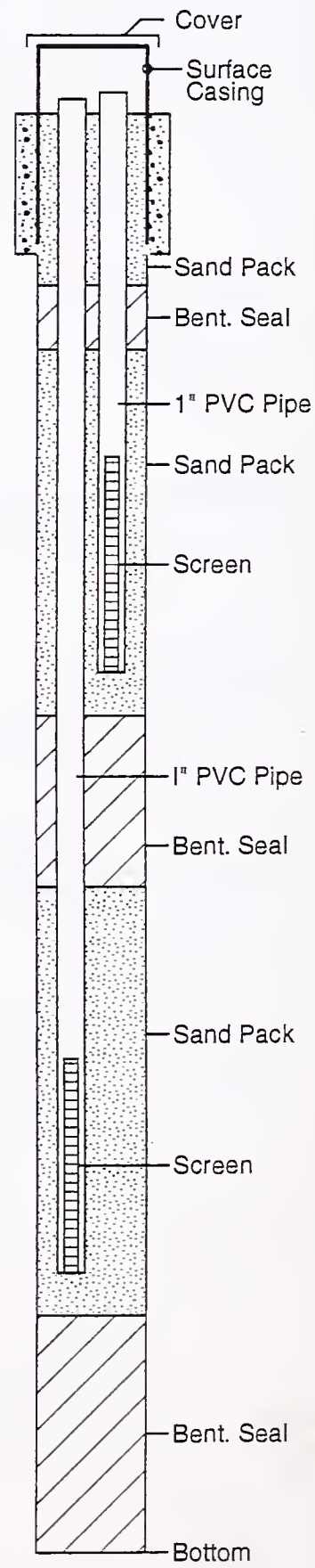
22 to 27 SCREEN FOR DH4A

28 to 33.5 BENTONITE

33.5 BOTTOM OF HOLE

Depth In Feet: 0, 5, 10, 15, 20, 25, 30, 35

Well1: DH-4A
Well2: DH-4B



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SOIL LOG OF BOREHOLE NO: DH5

MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Cottonwood	DRILL RIG	: Track B53
DATE STARTED	: 11/16/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/18/19997	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: tim Kuehn
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 5078.8	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	5078		0 to 5' GRAVELLY TOPSOIL, occasional cobbles, brown to dark brown, dry	GP								
5	5073	X	5 to 10' SANDY LEAN CLAY with some gravels, dark brown, moist	CL		SS	8 10 7	23	12/18	67%		5 to 6.5' % Finer #200 = 50%
10	5068	X	10 to 15' SAND, saturated	SP		SL	2 4 6	9	0/18	0%		
15	5063	X	15 to 33.5' SANDSTONE, light gray to gray, numerous fractures, most fractures appear water bearing	SS		SS	14 50		6.7/18	37%		15' Bedrock contact Stop augering, begin coring
			15 to 16.5' weathered, soft							80%		15 to 20' Cored 5' Recovered 4' RQD = 54%
20	5058		16.2 to 17' siltstone							91%		20 to 23.5' Cored 3.5' Recovered 3.2' RQD = 55%
			17 to 21' sandstone with rip-up clasts of siltstone							100%		23.5 to 28.5' Cored 5' Recovered 5' RQD = 92%
25	5053		21.5 to 28.8' conglomerate with sandstone matrix									
			28.8 to 33.5' sandstone							100%		28.5 to 33.5' Cored 5' Recovered 5' RQD = 99%
30	5048											Refer to digital photos in project file.
			33.5 BOTTOM OF HOLE									
35												

Hollow Stem Auger 4 1/2"
Core Barrel HQ3
HAmmer 140 lbs 30" drop free-fall hoist
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"

03-29-2005 ATER_RT\WRB-STAF\Bob A\Well Logs\Cottonwood Logs\Cottonwood DH-5 Soil.bor

WELL COMPLETION LOG NO: DH5

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Cottonwood	DRILL RIG	: Track B53
DATE STARTED	: 11/16/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/17/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Kuehn/Beck
DRILLER	:	APPROVED BY	: Kevin Smith

Depth In Feet | Surf. Elev. 5078.8

0 — 5078 — 5 — 5073 — 10 — 5068 — 15 — 5063 — 20 — 5058 — 25 — 5053 — 30 — 5048 — 35

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 11/17/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Jim Beck

STANDPIPE

Material	: PVC pipe
Diameter	: 1 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 1 inch
Length	: 5 feet
Opening	: .02 inch

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 7 inch
Length	: 5 feet

NOTES:

Surface Elev: 5078.80 feet

DH5A TOP Elev: 5079.03 feet

DH5B TOP Elev: 5078.90 feet

Top of Cover Elev: 5079.30 feet (estimate)

Northing: 10134.77

Easting: 10076.73

Surveyed By: Mike Lesnik

Date Surveyed: 1/25/2000

DESCRIPTION

0 to 5 SAND

5 to 7 BENTONITE

7 to 14 SAND

8 to 13 SCREEN FOR DH5B

14 to 18.5 BENTONITE

15 bedrock contact

18.5 to 29.5 SAND

23.5 to 28.5 SCREEN FOR DH5A

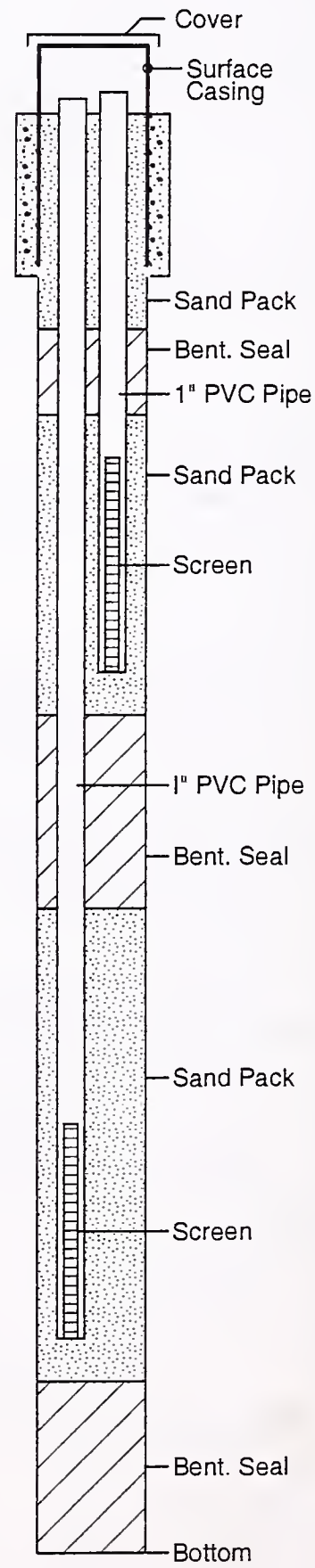
29.5 to 33.5 BENTONITE

33.5 BOTTOM OF HOLE

Depth In Feet

0 — 5 — 10 — 15 — 20 — 25 — 30 — 35

Well1: DH-5A
Well2: DH-5B



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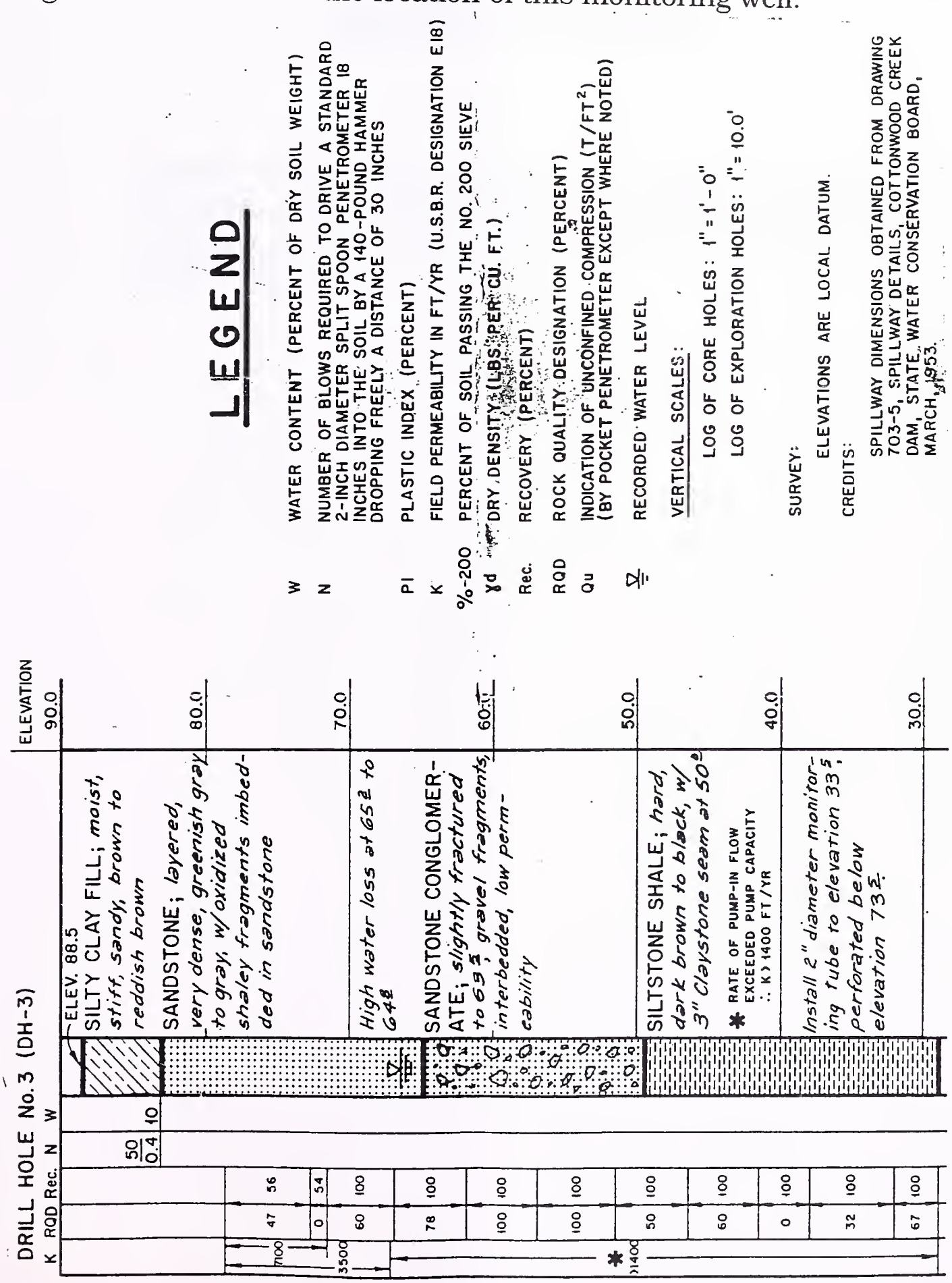
Note: Three drill holes were drilled in May 1982, but two of the holes were destroyed when the spillway was rebuilt. The remaining hole is located on the south side of the spillway. It was originally identified as DH-3, but has been renumbered to DH-6 to mesh with the drill holes drilled in 1999. See Figure 4 which shows the location of this monitoring well.



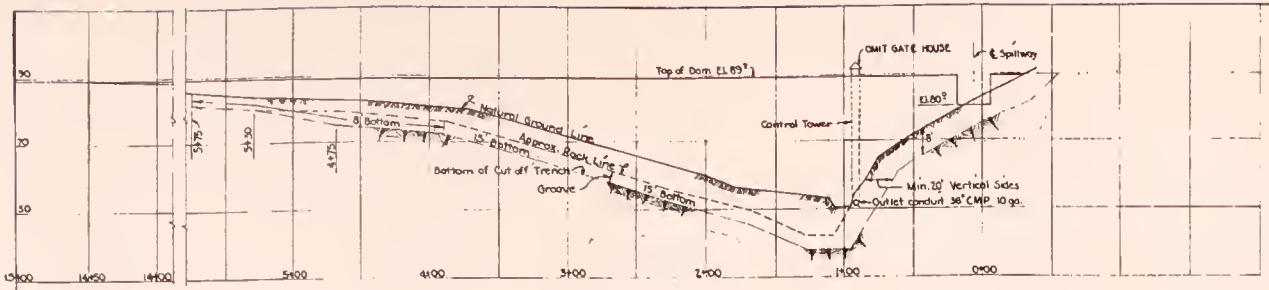
APPENDIX E

PROJECT DRAWINGS

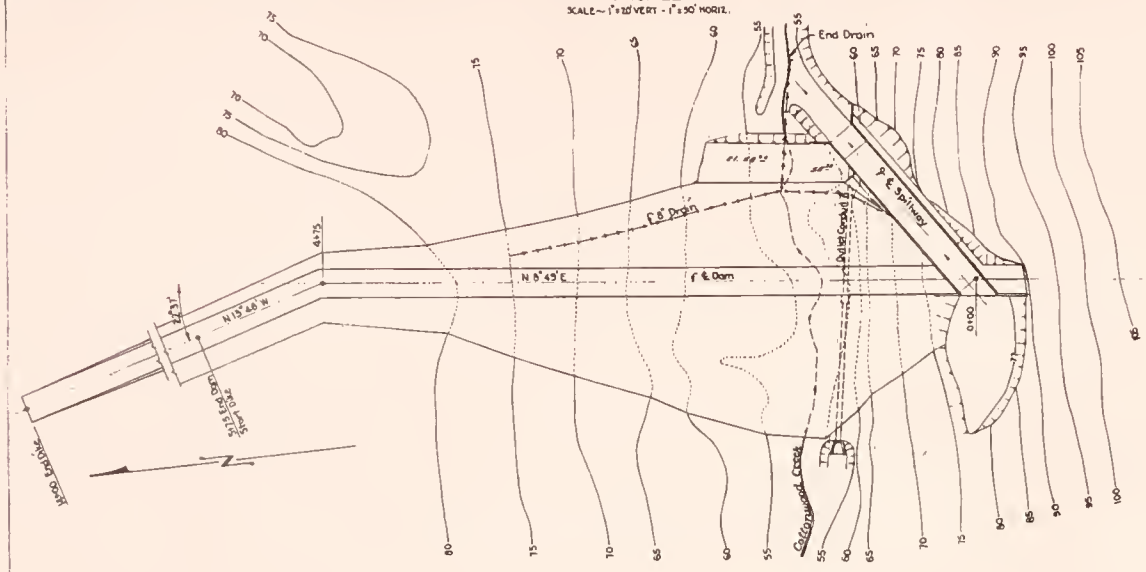
(NOTE: These reduced project drawings are design drawings and not "As Builts". These drawing should be used for reference only. The SWPB has the full size project drawings.)

E2

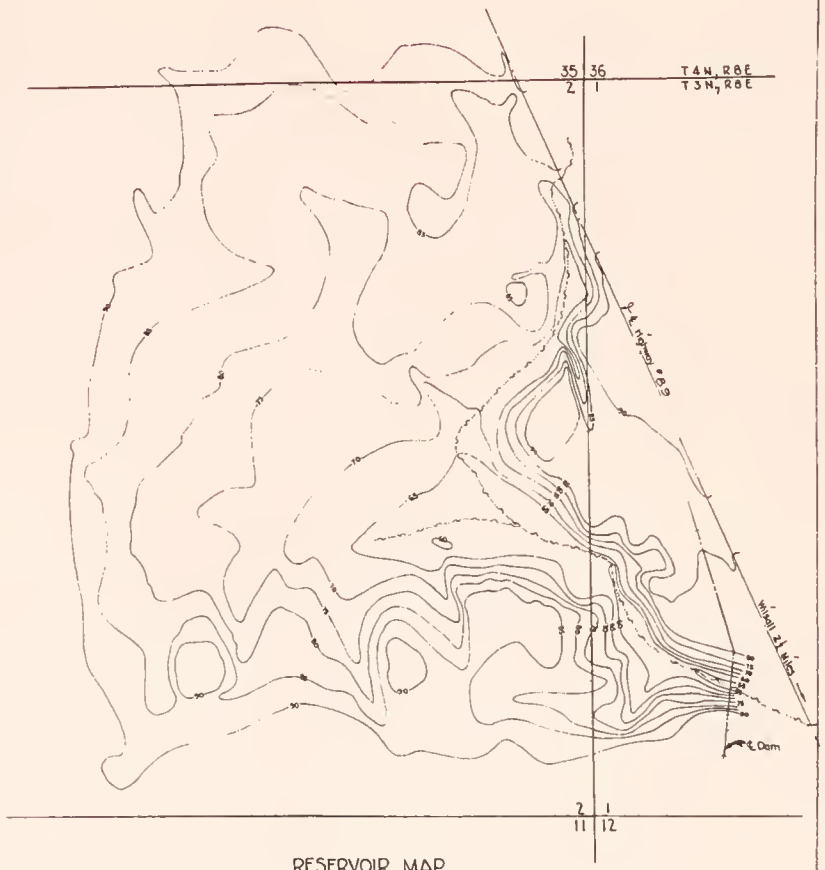
2005



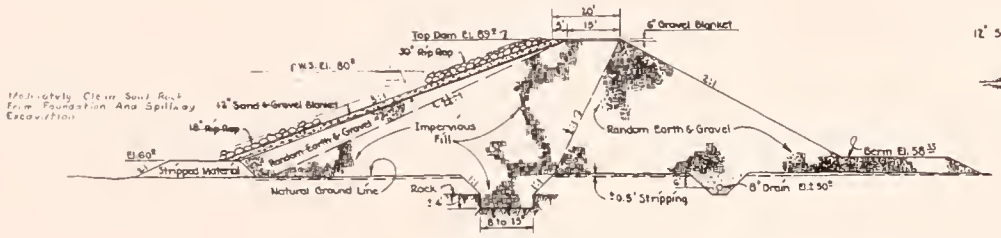
PROFILE
SCALE ~ 1" = 20' VERT. - 1" = 50' HORIZ.



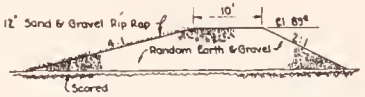
PLAN
SCALE ~ 1" = 50'



RESERVOIR MAP
SCALE ~ 1" = 500'



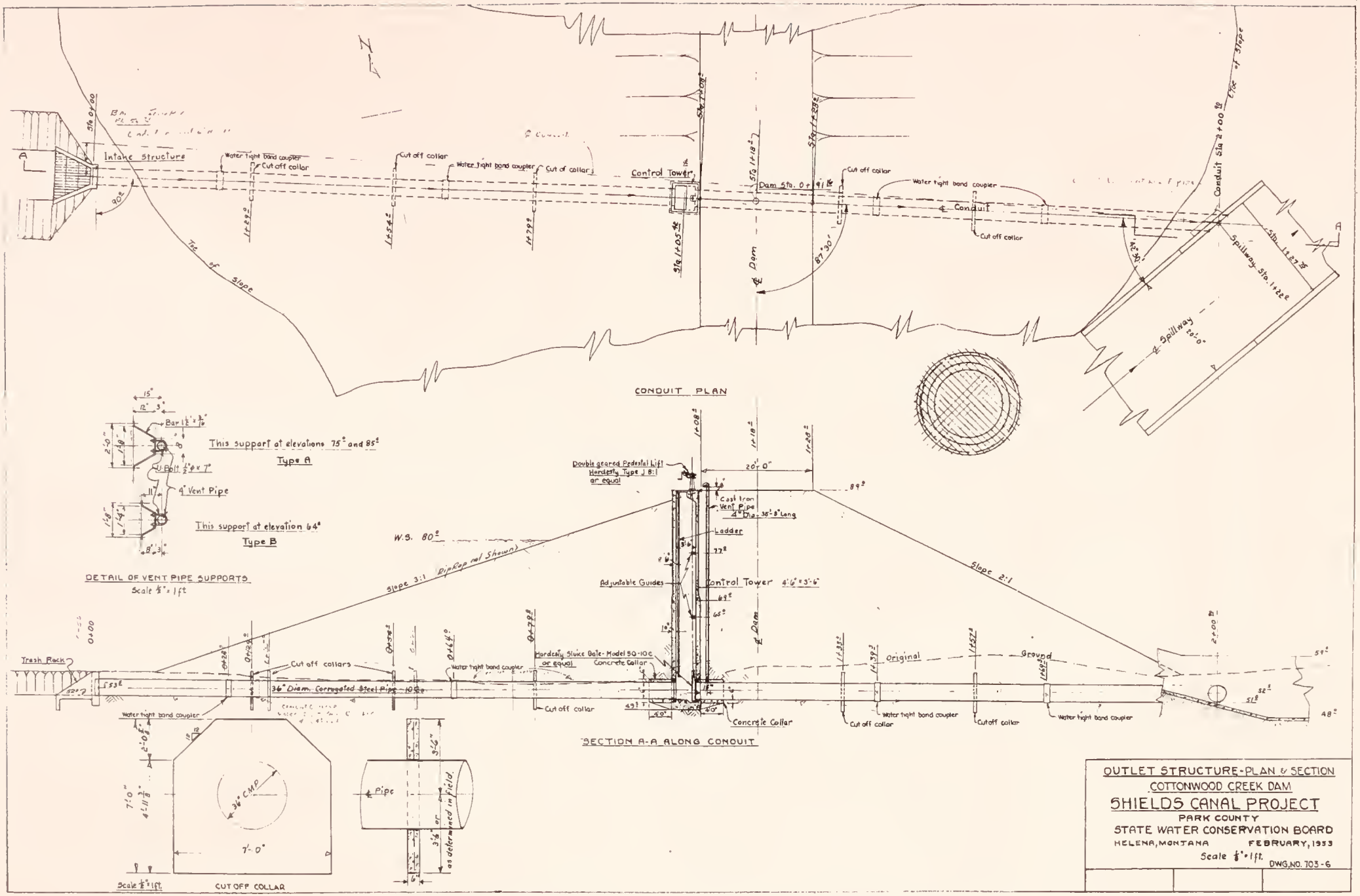
TYPICAL SECTION
SCALE ~ 1" = 10'
END OF DAM SECTION & ROCK RIP RAP AT 5+75

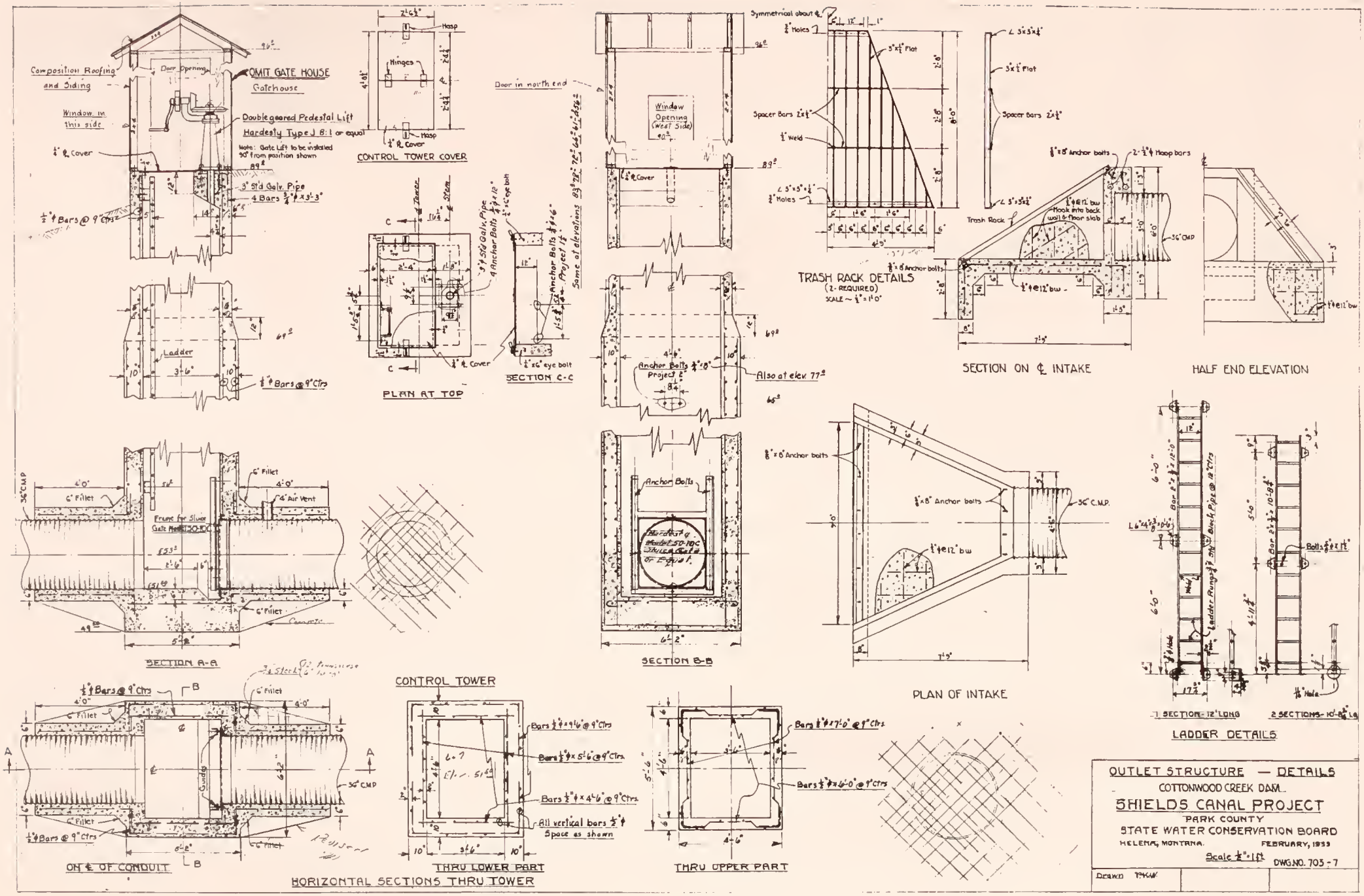


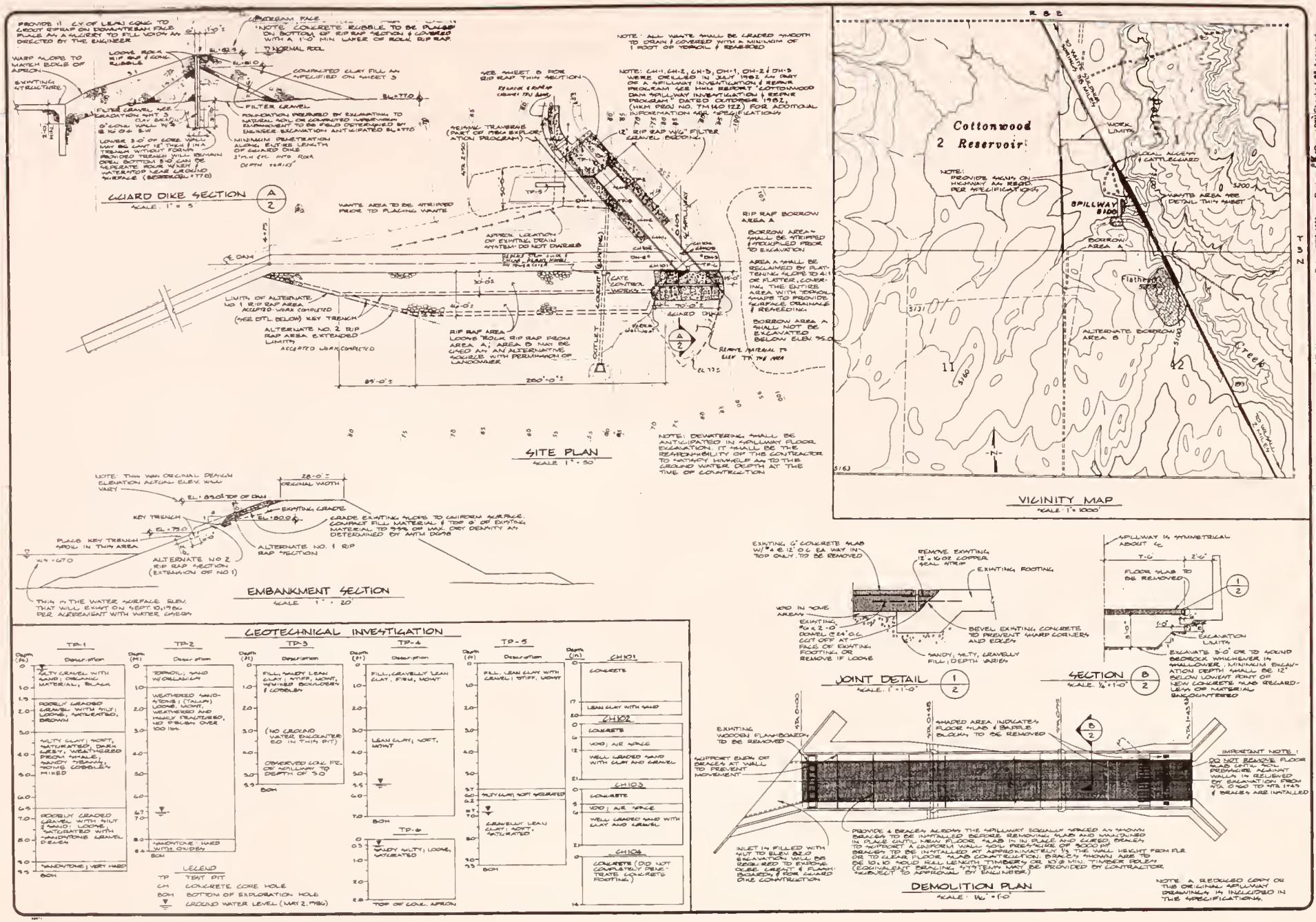
TYPICAL DIKE SECTION
SCALE ~ 1" = 10'
DIKE SECTION FROM 5+75 TO 14+00
END GRAVEL RIP RAP AT 8+50

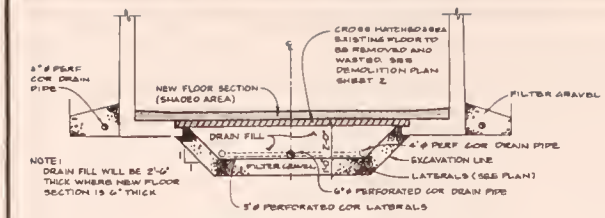
DETAILS OF DAM - COTTONWOOD CREEK
SHIELDS CANAL PROJECT
PARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA APRIL 1955
SCALE AS SHOWN
DWG. NO. 703-4

B-703-4


Intake Structure
Water tight band coupler
Cut off collar
Control Tower
Dam Sta. 0+91
Conduit
Spillway Sta. 1+22
Spillway 20'-0"
Toe of Slope
CONDUIT PLAN
This support at elevations 75° and 85°
Type A
This support at elevation 64°
Type B
DETAIL OF VENT PIPE SUPPORTS
Scale ½" = 1ft
Double geared Pedestal Lift
Hardesty Type J 8:1
or equal
Cast Iron Vent Pipe
4" Dia. - 38'-8" Long
Ladder
W.S. 80°
Slope 3:1
Slope 2:1
Adjustable Guides
Control Tower 4'-6" x 3'-6"
Trash Rack
36" Diam. Corrugated Steel Pipe
Hardesty Sluice Gate - Model SQ-10C
or equal
Concrete Collar
Original Ground
SECTION A-A ALONG CONDUIT
36" CMP
Pipe
as determined in field
CUTOFF COLLAR
Scale ½" = 1ft.
OUTLET STRUCTURE-PLAN & SECTION
COTTONWOOD CREEK DAM
SHIELDS CANAL PROJECT
PARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA
FEBRUARY, 1953
Scale ⅛" = 1ft.
DWG. NO. 703-6


Composition Roofing and Siding
Door Opening
OMIT GATE HOUSE
Gatehouse
Window in this side
Double geared Pedestal Lift
Hardesty Type J 8:1 or equal
Note: Gate Lift to be installed 90° from position shown
3" Std Galv. Pipe
4 Bars 3/4"φ x 3'-3"
Ladder
CONTROL TOWER COVER
Hasp
Hinges
PLAN AT TOP
SECTION C-C
Door in north end
Window Opening (West Side)
Anchor Bolts
Also at elev. 77
SECTION B-B
TRASH RACK DETAILS
(2-REQUIRED)
SCALE ~ 1/4" = 1'-0"
Spacer Bars
Trash Rack
SECTION ON ℄ INTAKE
HALF END ELEVATION
SECTION A-A
Frame for Sluice Gate Model 30-RC
PLAN OF INTAKE
LADDER DETAILS
1 SECTION - 12' LONG
2 SECTIONS - 10'-8 1/2" LG
ON ℄ OF CONDUIT
CONTROL TOWER
THRU LOWER PART
THRU UPPER PART
HORIZONTAL SECTIONS THRU TOWER
OUTLET STRUCTURE — DETAILS
COTTONWOOD CREEK DAM
SHIELDS CANAL PROJECT
PARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA.
FEBRUARY, 1933
Scale 1/4" = 1'-0"
DWG. NO. 705-7
Drawn


GUARD DIKE SECTION
SITE PLAN
VICINITY MAP
EMBANKMENT SECTION
GEOTECHNICAL INVESTIGATION
JOINT DETAIL
SECTION
DEMOLITION PLAN
Cottonwood 2 Reservoir
SPILLWAY
BORROW AREA A
ALTERNATE BORROW AREA B
Flathead
Creek
T 7 N
R 8 E
COTTONWOOD DAM
SPILLWAY REHABILITATION PROJECT
SITE PLAN AND DEMOLITION PLAN
HKM ASSOCIATES
ENGINEERS-PLANNERS
Airport Industrial Park
P.O. Box 31318
Billings, Montana 59107
Branch Offices:
Libby, Montana
Sheridan, Wyoming
Sheet No 2 of 4
5-703-13



TYPICAL DRAIN SECTION

SCALE: 1/4" = 1'-0"

FILTER GRAVEL GRADATION SPECIFICATION	
SIEVE SIZE	PERCENT PASSING
1 1/2 in	100
3/8 in	70 - 100
No. 4	50 - 70
No. 20	20 - 45
No. 50	0 - 26
No. 100	2 - 15
No. 200	0 - 9

DRAIN FILL GRADATION SPECIFICATION	
SIEVE SIZE	PERCENT PASSING
1 1/2 in	100
3/8 in	50 - 100
No. 4	20 - 40
No. 20	5 - 15
No. 50	0 - 5
No. 100	0 - 2

COARSE GRAVEL GRADATION SPECIFICATION	
SIEVE SIZE	PERCENT PASSING
6 inch	100
No. 4	30 - 55
No. 200	0 - 15

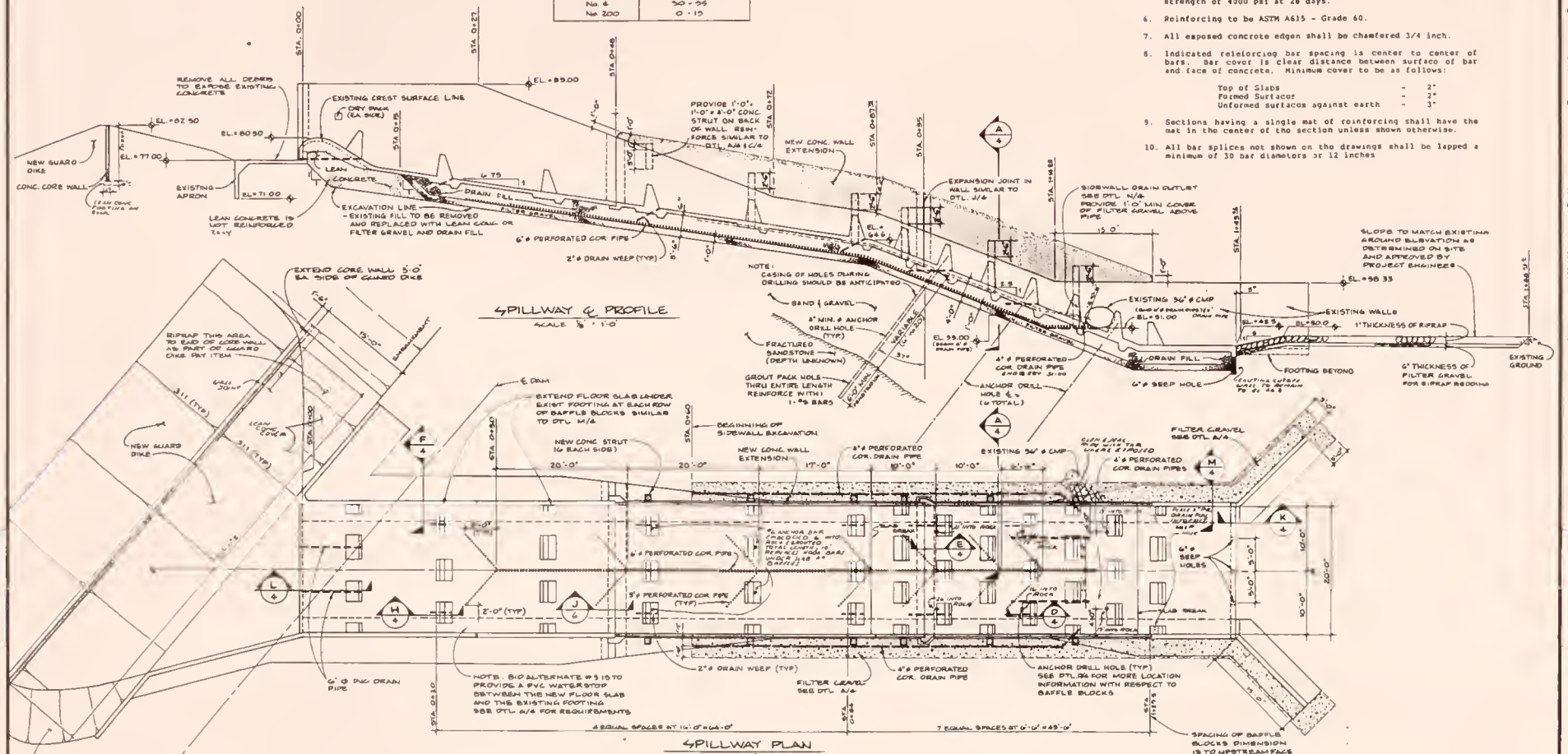
THE COMPACTED CLAY FILL SHALL HAVE AT LEAST 50 PERCENT PASSING THE NO 200 SIEVE, A PLASTICITY INDEX EQUAL TO AT LEAST 8 SEE SPECIFICATION SECTION 02200.

GENERAL NOTES

1. All elevations are in feet. Benchmark is concrete base of control tower. (El = 89.00, Project Datum, not verified with NGVD).
2. All stationing refers to control line of construction and is the horizontal distance.
3. Rock anchor lengths are shown for bidding purposes. Actual lengths will be field determined to achieve 6 ft. minimum rock penetration.
4. Excavation under existing spillway slab to be a maximum of 36 inches deep or to bedrock whichever is shallower. Minimum excavation depth shall be 12 inches below lowest point of new concrete slab regardless of material encountered.
5. Cast-in-place concrete shall have a minimum compressive strength of 4000 psi at 28 days.
6. Reinforcing to be ASTM A615 - Grade 60.
7. All exposed concrete edges shall be chamfered 3/4 inch.
8. Indicated reinforcing bar spacing is center to center of bars. Bar cover is clear distance between surface of bar and face of concrete. Minimum cover to be as follows:

Top of Slabs	-	2"
Formed Surfaces	-	2"
Unformed surfaces against earth	-	3"

9. Sections having a single mat of reinforcing shall have the mat in the center of the section unless shown otherwise.
10. All bar splices not shown on the drawings shall be lapped a minimum of 30 bar diameters or 12 inches



No	Revision	By	Date

Drawn Checked Approved

Designed Date June 1988

Project No 14087.189 ID No

COTTONWOOD DAM
SPILLWAY REHABILITATION PROJECT

PLAN AND PROFILE

HKM ASSOCIATES
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• Libby, Montana
• Sheridan, Wyoming

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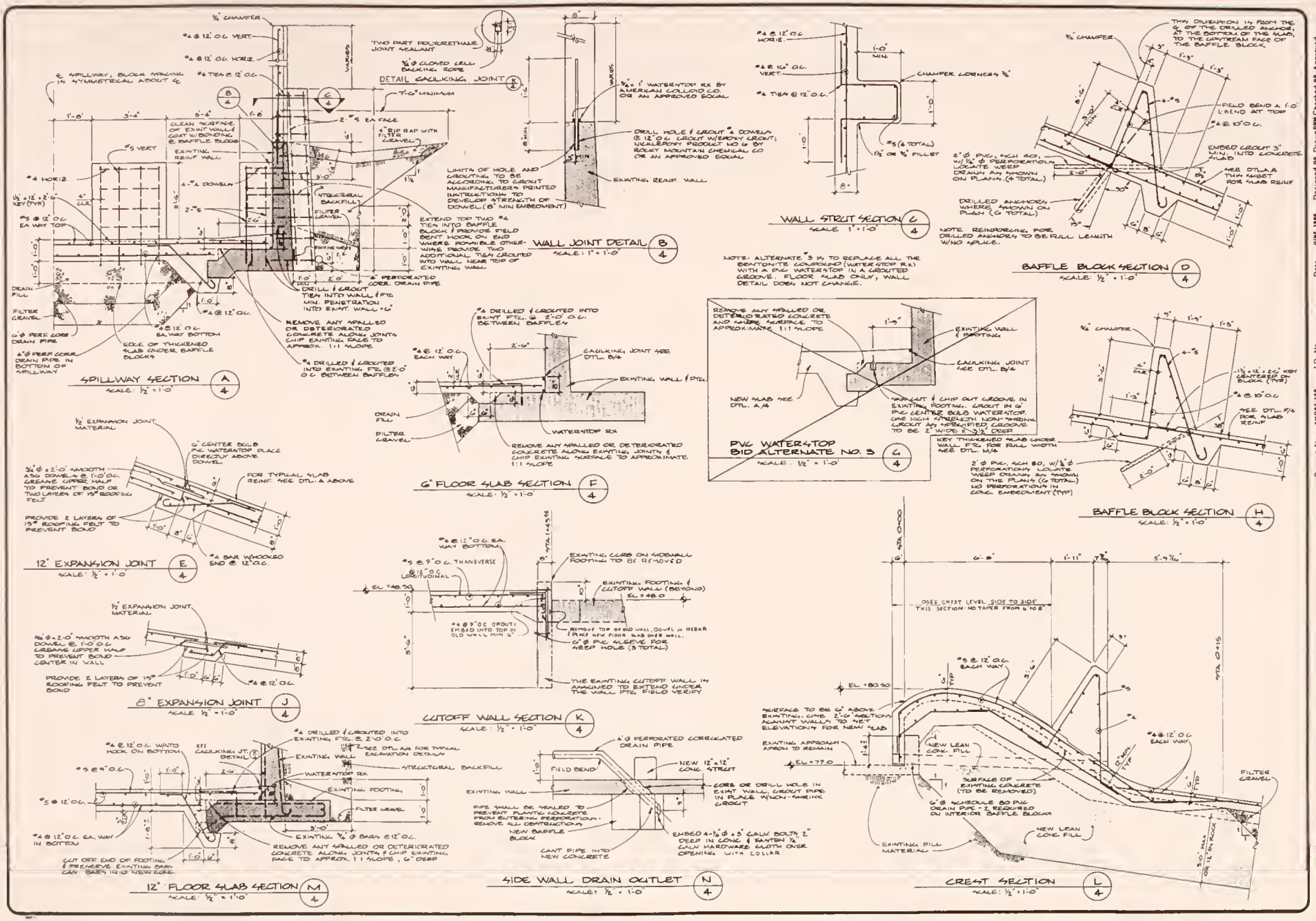

No	Revision	By	Date

Designed as Drawn BMB Checked BB Approved

Date JUNE 1989

Project No. 1W0021.388 ID No.

COTTONWOOD DAM
SPILLWAY REHABILITATION PROJECT
SECTIONS AND DETAILS

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5-703-15